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Applied Disaster Research is the title of the proceedings volume of the first Disaster, Risk and Vulnerability Conference DRVC 2011. The aim of the conference as well as of the publication is to provide an arena for researchers and professionals in diverse specializations to come together with their publications in an area of common interest, viz, Disaster Research. The conference is a partner conference of the annual Applied Geoinformatics for Society and Environment series of conferences, of the Stuttgart University of Applied Sciences, Germany. The scope of this publication spreads from the sociology and psychology of disasters to mathematical modelling, risk and vulnerability estimates to prediction of large-scale disasters. It spans the wide area between the pure sciences, engineering and the social sciences. Authors are hence encouraged to publish their Applied Disaster Research work in this journal. The thematic areas that would be addressed are (but not limited to): (1) Disaster Management and Public Administration (2) Disaster Research and Practices (3) Community Approaches in Disaster Management (4) Interdisciplinary approaches in Disaster Management (5) Emergency Medicine and Management (6) Geology and Disasters (7) Fire and Rescue Operations (8) Adaptive Strategies (9) Engineering Disaster Mitigation and Management (10) Disaster Education and Knowledge Management (11) Spatial technologies in Disaster Management (12) Hazard Risk & Vulnerability Analysis Natural/Financial (13) Statistics of Risk Analysis.

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Preface

The Disaster, Risk and Vulnerability Conference 2011 (DRVC2011) (www.disasterresearch.net) started out of the desire to see Disaster Professionals and students coming together from different disciplines and out of the idea that such a gathering of minds from disparate disciplines, but with the common chord of 'disaster' interlinking their interests would throw up interesting insights into this nascent field of study. It is a well-recognized fact that interdisciplinary research is the need of the hour, and this is especially true for the field of Disaster Management (DM). Conferences act as foci for exchanging ideas and for establishing new collaborations. Vibrant discussions make conferences come alive. This compendium of papers from the DRVC2011 shows that the field of DM derives inputs from fields as far-ranging as Artificial Intelligence and Cumulus modelling to Psychology, Social mapping and onto Retrofitting and Structural Mapping. The premier research support and promotion agencies in India like the Department of Science and Technology, Ministry of Earth Sciences and National Disaster Management Authority extended financial support to the conference, and this has helped us immensely in the proper organization of the conference and helped us in bringing out the conference proceedings without delay. The MG University is also thanked for the financial support and infrastructural facilities provided.
The University needs special appreciation for having had the prescience to initiate India's first full-time MSc program in Disaster Management in 2006.

The support we have received from the State Disaster Management Authority is also thanked and we hope this conference will help in establishing strong links between the academia and the Government as represented by the SDMA and ILDM. The IMA DM Cell Kerala deserves our thanks for coming up with the proposal for a session on Emergency Medicine. Similarly the NDRF is thanked for their exhibition and demonstration on disaster equipments. Their quiet confidence and professionalism is reassuring in our times of exponentially increasing natural and man-made disasters. We also thank all our colleagues, students, researchers and staff of the School of Environmental Sciences, as well as of the Advanced Centre of Environmental Studies and Sustainable Development, MG University who took an active interest in the organization of the conference. Prof. A.P.Thomas is thanked for planting the idea of the conference.

Last but not the least, it is you, the discerning participant, who is to be thanked, for your dedication to the cause of learning and research and for taking pains to come over to this southern tip of the Indian subcontinent in pursuit of excellence in Disaster Research.

Kottayam, India
12 March 2011

Dr.A.P.Pradeepkumar
Convenor, DRVC2011

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An emergency essential service module for natural disasters

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ABSTRACT

Bangladesh is a disaster prone, with frequent natural calamities. Each natural calamity brings with it devastation and an influx of environmental refugees to cities. It was to address the plight of this extremely needy population that it was decided to design an appropriate emergency essential services module that could be used as the base for distributing relief in goods and services when disaster strikes. The idea was that the module could be easily assembled on disaster sites and easily dismantled and stowed away when relief was no longer needed. A research project was initiated to look into appropriate materials and techniques of assembly which would be ecologically and environmentally sustainable, while being affordable and efficient. This paper discusses a method through which this specific problem is approached, firstly by analyzing the work of students of Architecture, who were assigned the project in their academic curriculum, and then by identifying problems and seeking solutions to the gaps. When the solutions are then assigned to specific sites, local conditions, materials, climate and building techniques, they all interact to influence the ultimate module that would be appropriate for the given site.

1 Introduction

1.1 Background and scope of study

Bangladesh is most vulnerable to several natural disasters and every year natural calamities upset people's lives in some part or other of the country (Coastal zone policy, 2005). The geographical setting of Bangladesh makes the country vulnerable to natural disasters, like floods, cyclones and storm surges, flash floods, riverbank erosion, and landslides. The mountains and hills bordering almost three-fourths of the country, along with the funnel shaped Bay of Bengal in the south, while making the country a meeting place of life-giving monsoon rains, also expose it to the catastrophic ravages of natural disasters (Karim 1993). Its physiographic and river morphology also contributes to recurring disasters. Abnormal rainfall, earthquakes and deforestation in the adjacent Himalayan range add to the disaster situation.

In Bangladesh, coastal areas are ecologically sensitive and climatically vulnerable because of the continuous process of erosion and accretion, which needs to be protected for natural vegetative growth and a forestation. It also contains one of the largest (5000 sq. km) mangrove forests in the world. The area covers over 6.8 million of households in 147 *Upazila* (Sub-district) along the coastal belt (BBS, 2003), which considered as risk prone. These areas generate substantial environmental refugees every time a natural disaster occurs.

A research project was initiated recognizing this natural propensity for disasters in Bangladesh, aiming to directly help environmental refugees. An Emergency Essential Services module is proposed to cope with the immediate aftermaths of natural disasters when vast multitude of population is faced with homelessness having neither food, nor a roof over their heads. The module will serve as sheltered space to distribute emergency services that are essential for theses environmental refugees for survival, viz. facilities like first aid, medical unit, and unit for dry food/goods storage, relief distribution areas, etc. Of necessity such a module should be built with local material and technology — buildable in a very short time with minimum cost.

Conceptually the module would be an immediate solution that can be built overnight when needed and dismantled and stowed away when the need disappears — to be available for reuse once again when disaster strikes again. The paper will focus a specific case study cyclone prone site after a design exercise where such a module will be designed as an outcome of this research project.

A design exercise is conducted with students which as studio project for understanding the need and process. Real scale model was build for proper understanding. After analysis and synthesis a design module will be proposed according to previous collected information. Forms and functional space suitable for various disasters for particular coastal region in Bangladesh need to study after the design exercise. At the end Design of easy to handle assembly system for the module, including members and joinery.

1.2 Objective of the research

As Bangladesh is a land where disaster management is essential; we need more effective disaster management system in the future. In present scenario Bangladesh is well capable of managing disaster than before in course of time. But with huge population with minimum resource we need more effective and essential disaster management system. The major objectives in this paper are as followings:

(1) Understanding the nature of disaster and after disaster need for build an emergency module system. Analysis of the specific coastal area for their specific need.

(2) A studio workshop/design exercise for understanding the form, need, material and technology of emergency essential module.

(3) The main objectives is to study and search for an emergency essential module for cyclone-affected area with easy buildable material and with local technologies.

2 Academic approach to the design

2.1 Design exercise

For understanding the need, technology and buildability a student project was introduced in the year 2010 for a design exercise. The project was conducted with third year First semester students as their design exercise which was suppose to build by students with the guidance of studio tutor. This project has been assigned to raise awareness among the students of Architecture about their social responsibilities and about the reality that is faced by a majority of the disadvantaged population of Bangladesh. Emergency Essential Services Module for Environmental Refugees: *a hands-on project* was named for the project. The students, in groups of six, are expected to:

Figure 1. Project 01 of design exercise.

(1) Study post-disaster phenomena and immediate needs faced by environmental refugees.

(2) Study disaster management undertaken in Bangladesh.

(3) Design the module which is easily buildable and constract the module in the original scale with available low cost materials.

(4) The overall process will let architecture students test their design, communication, and problem solving skills while providing a service to the community.

2.2 Design of module and analysis

In the design exercise diversified type of projects were encouraged. In different project different kinds of solution were the outcome with differ technology and materials. It was a design exercise of group of six students and the duration was 3 weeks. In three phases the exercise was conducted. At first they did some study on disaster management and materials. In the second week they design the projects in small scale to understand the advantages and disadvantages. And in the last phase they build the project in real scale with the help of workshop. Project 01 was the most efficient one among all projects as it was very easy to build and easy to dismantle. Total weight of the structure is only 3 kg and one can carry and install it very easily. Two people can install or dismantle the module in 5 minutes. This structure of the module is made of PVC (poly vinyl chloride) stick and PVC joint. And the group covered the structure with synthetic fabric and fixed with nylon rope. The base was made of metal which can anchored is the soft soil easily (Figure 1).

The project 02 (Figure 2) was less effective on terms of mobility and takes more time to install. It was rather less stout than the first one. It was comparatively larger one with PVC pipe with metal joints structure and

Figure 2. Project 02 of design exercise.

Tarpaulin to cover it. The structure finds difficulties to stand against wind which is negative for windy area or cyclone prone area.

The Project 03 (three) (Figure 3) was also an interesting with folded structure which can build in different size by adding module. It is also easy to install and dismantle. And it is also a movable structure. The structure is made of aluminum with hinge aluminum joints and covering with light synthetic fabric. The structure also takes minimum time to install and to dismantle. For structural stability the module joints need stronger in this design.

The project 04 (four) (Figure 4) is also very interesting in terms of modular design which was made of PVC pipe and metal joints with synthetic fabric or hard polythene cover. This module is multiply to any numbers and it is a freestanding module. The structure is easy to install and to dismantle. The module can be made by anyone with locally available material like bamboo, synthetic fabric, rope and water pipe connector.

Project 05 (five) (Figure 5) was not very successful one in terms of its flexibility, stoutness and functionality rather it was a weak project without strong structure and proper shading. The structure was made with paper-pipe and connected with larger paper pipe and covered with synthetic fabric. The attempted was a good one in terms of exploration of different material but the material is also not suitable for water based muddy ground, rain and even structure durability.

Project 06 was also explored a different kind of structure with single column and a metal connector. The synthetic cover will work as tension cable for the structure. The structure or frame is made of bamboo. Structurally the emergency module is little unstable and need strong ground to fixed it.

Figure 3. Project 03 of design exercise.

2.3 Outcome of design exercise

After the design exercise certain decision can be made for further study and final module design.

Figure 4. Project 04 of design exercise.

Figure 5. Project 05 and 06 of design exercise.

The followings are the overview after the design exercise:

(1) Structure is an important part for designing the emergency service module. Structure must be strong to stand in the adverse weather. It is preferable to have a free-standing structure for the disaster emergency module.

(2) It is very important to make the module with easily available material with simple technology to make multiple number of structure when emergency occur. Structure must be economic for disaster management.

(3) Structure should be mobile and easily installed for effective and efficient use of it. The module should be dismountable and with minimum time. The technology should be simple to be installed by any one.

(4) The emergency module must be able to perform multiple uses.

3 Present scenario and selection of site

3.1 Present scenario

Bangladesh is currently ranked as one of the world's most disaster-prone countries, with 97.1 per cent of its total area and 97.7 per cent of the total population at risk of multiple hazards, including cyclones (Alam & Collin, 2010). The frequency of natural disasters has increased in recent years. Since independence in 1971, the country has endured almost 200 disaster events — cyclones, storm surges, floods, tornadoes, earthquakes, droughts and other calamities — causing more that 500,000 deaths and leaving serious impacts on quality of life, livelihoods and the economy (Kabir, 2009).

In Bangladesh the current situation of post disaster activities is not well organized as expected though in recent time disaster management system is improved in case of saving the human life. There is less connection between the different NGOs and government departments. As a result in some areas people may get relief and some not. Bangladesh is also technologically least developed with large population where illiteracy rate is high and with minimum resources post disaster management system is not well organized. Schools, Colleges, cyclone shelter, Government offices are now used as cyclone shelters which does not consist any type of proper basic facilities like toilets, water supply, first aid and even places for keeping the relief goods safely. For proper post disaster management above mentioned points must be addressed where essential emergency module can play a significant role (Figure 6).

3.2 Selection of the study area

There were some predefined priorities for selecting the site: (a) Most cyclone affected area which is affected almost every year, (b) Coastal region, (c) Most vulnerable area, (d) a region that full of natural resources. These above mentioned priorities helps to select the study area **'Kuakatave' in Patuakhali** because of following reasons:

- Kuakata is a coastal area which is vulnerable to natural disaster.

- This area was having the experiences of cyclones repeatedly for long time. Almost every cyclone that passes Bangladesh the selected area had experienced directly or indirectly damages.

Figure 6. (A) Relief coming by boat, (B) Cyclone shelter, (C) Distribution of relief, (D) Temporary shelter made by local people. (Source: Daily Star, NewAge, Internet.)

Figure 7. Existing type of structures (building technology) including cyclone shelters.

- The selected study site is on the coast which has 18 km beach area. Kuakata is one of the two beaches (other one is in Japan) from where we can see the blood red Sunrise and Sun set (Views on Tourism, 2010).
- The people lives in Kuakata including the Rakhains (tribal race) are also dependent on the sea for their living. Being fishermen for very long time and this made them more experienced in the sea in cyclone (Hasan 2008).

3.3 Kuakata

Kuakata in Latachapli union (sub-district) under Kalapara Police Station of Patuakhali district is about 30 km in length and 6 km in breadth. It is 70 km from Patuakhali district headquarters and 320 km from Dhaka. At Kuakata there is excellent combination of the picturesque natural beauty, sandy beach, blue sky, huge expanse of water of the Bay and evergreen forest. Kuakata is one of the rarest places which has the unique beauty of 18 km long and 3.5 km wide and offering the full view of the rising and setting of crimson sun in the water of the Bay of Bengal in a calm environment (Views on Tourism). Kuakata is a unique example of co-occurrence of different ecosystems. There are remnants of mangroves in this beach. The line of coconut trees has increased the scenic beauty of this seashore. The nearby Fatra and Gangamati mangrove forests (part of Sundarbans) have enriched the biodiversity of this territory. The tamarisk (Jhou) forests have added more attraction to this beach (Views on Tourism). According to 'Cyclone Shelter Information Database', Bangladesh the selected area has 13 cyclone shelters. The Kuakata area has a particular type of building due to their specific context. Local technology is also very interesting which can be a good study to build the final design (Figure 7).

4 Recommendations and conclusion

Bangladesh is a land of natural disasters — whether in the form of floods, river erosion, cyclones, drought or earthquakes — and the phenomena are growing increasingly frequent in recent times. Climate change is aggravating the phenomenon and making them recur almost every season. This is also an earthquake-prone area, a truth that has alarmingly been brought to the forefront with a series of small earthquakes in the last couple of years. As a developing country Bangladesh is not very equipped with its disaster management, and consequently environmental refugees are increasing in alarming proportion. Architects, as designers of the built environment have a social responsibility towards addressing this situation. In present practice, Architects mainly serve a rich section of society, while a vast majority, in dire need of appropriate technology and knowledge, is deprived of their expertise. The realization is slowly emerging that unless Architects, with their undeniable problem-solving training, engage with society and impart their skills, development will be hampered and the sustainability of the environment will be endangered.

As a cyclone effective belt, southern coastal area of Bangladesh is very venerable where disaster management is a major part. Emergency disaster service is a common need in case of Bangladesh where essential service can play an effective role. After preliminary survey, design exercise and selection of specific area for work, the final phase is to build a module after specific test like structural test, wind test etc. With analysis and synthesis final module is to design in a specific site with the study of local technology. Through the findings of design exercise final design outline is to be finalized. As Bangladesh is a developing country with minimum resources, sustainable post disaster management system is essential for the country. Bangladesh has many disaster shelters in the coastal areas which are permanent and used as schools in most of the cases. This emergency essential module can be easily built with local technology, which can be moved easily with easy installation and dismantle system. This emergency service will be easily reachable in the remote area and can perform multiple uses. Even after initial service this module can be used as temporary shelters for the homeless people. The final design will conduct with different multidisciplinary people for effective and efficient outcome with simple technology which will act as a sustainable module for post disaster emergency need.

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Landslides in coastal Uttara Kannada: Management towards risk reduction

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ABSTRACT

The hilly coast of Uttara Kannada, interrupted with backwaters and river mouths, had no notable history of landslides until multiple slides struck Karwar during the rain-soaked early days of October 2009 causing live burial of 19 persons. That the proneness of the region to landslides has increased due to rising human impacts can be assumed considering the collapse of a hillside along Kumta coast during the peak rainy days of 2010 and in yet another incident near Karwar, boulders rolling down a steep hill hit a running train causing one death and injuries to others.

A combination of factors may be blamed for the landslides that happened and likely to repeat, especially during days of excessive rains which are on the rise. Low lateritic coastal hills are formed of eroded and re-deposited materials from the Western Ghats through geological ages. Vegetation flourished on these hills until pressures from rising population and developmental activities erased bulk of it. The exposed soils of denuded hills got laterised through surface erosion, fine clay materials seeping down into the lower horizons leaving honey-combed iron rich, indurated surface laterite, a poor terrain for plant growth. The indurated surface laterite is an effective shield against landslides, except when deep vertical cuts are made exposing the soft clayey soil horizon beneath.

The vulnerability of deposited lateritic hills to landslides increases if such deposits have taken place along the river courses or estuarine regions, causing capillary rise of water from beneath and descend of rain water through fissures and holes formed by rotten tree stumps. Rainy spells can soak up the soft soils in the interior triggering mudslides due to rupture of the hills, as is the case with the killer landslide at Kadwad in Karwar. Quarrying, pediment cutting, soil removal and stripping of vegetation increase risks.

The granitic hills of Karwar coast are also posing potential landslide problems. The rocks here are of fractured type with ample pockets and cracks with trapped soils. Good forest cover could minimize risks. Deforestation in these is at its peak, caused erosion of top soil and water seepage into the interior of hills. Whereas the soils soak up and expand the granite rocks do not, unlike the laterite. Heavy rainfall acts as triggering cause for landslide hazards in such hills. Pediment cutting and quarrying add to the risk factor.

Probable landslide prone areas in Uttara Kannada district and also in Kerala were predicted using algorithms — GARP (Genetic Algorithm for Rule-set Prediction) and Support Vector Machine (SVM) in a free and open source software package — openModeller. Several environmental layers such as aspect, digital elevation data, flow accumulation, flow direction, slope, land cover, compound topographic index, and precipitation data were used in modelling.

A comparison of the simulated outputs, validated by overlaying the actual landslide occurrence points showed 92% accuracy with GARP and 96% accuracy with SVM in predicting landslide prone areas considering precipitation in the wettest month whereas 91% and 94% accuracy were obtained from GARP and SVM considering precipitation in the wettest quarter of the year.
To prevent landslide hazards, there should be accepted norms for each region, based on composition of soil and rocks, rainfall, quality and biomass of vegetation etc. Reduction of risk factor lies in providing appropriate vegetation cover, and any interference with the hills should be strictly adhering to norms of geology and ecology of the region.

1 Introduction

Landslides, around the world, take a heavy toll on life and property every year. Indeed, they are one of the most significant contributors to loss of life and aggregate national losses caused by natural disasters associated with earthquakes, severe storms and heavy rainfall in mountainous terrain Lundgren, 1986; Swiss Reinsurance Co., 2000). Sediment disasters by debris flows, mud flows, and landslides occur almost every year during the rainy and typhoon period of July to October in Japan. In July 1982, a heavy rainfall of 488 mm in a day caused 4300 debris flows in Kyushu Island killing 299 people. Many debris flows caused by intensive rainfall during July 1983, in Honshu Island killed 199 people. Both created also enormous loss of property (Abe and Ziemer, 1990). Considered some of the worst ever natural disasters in Brazil, 806 people were killed and hundreds were yet to be traced killed as cloudburst triggered avalanches of mud and water ripped through already water-soaked mountainsides in January, 2011 (*Geology & Earth Sciences*, 2011; *Scientific American.com*, 2011). The month also saw such disasters worldwide as floods and landslides caused devastation in Australia, China and Sri Lanka.

2 Types of landslides

Landslides are classified by causal factors and conditions, and include falls, slides and flows. There are many attributes and criteria for identification and classification including rate of movement, type of material and nature of movement (Ramachandra *et al.*, 2009).
Falls: Falls move through the air and land at the base of a slope. Material is detached from a steep slope or cliff and descends through the air by free fall or by bouncing or rolling down slope. Rock fall, the most common type, is a fall of detached rock from an area of in tact bedrock.
Slide: Slides move in contact with the underlying surface. They include rockslides — the down slope movement of a rock mass along a plane surface; and slumps — the sliding of material along a curved (rotational slide) or flat (translational slide) surface. Slow moving landslides can occur on relatively gentle slopes, and can cause significant property damage, but are less likely to result in serious injuries.
Flows: Flows are plastic or liquid movements in which mass (e.g. soil and rock) breaks up and flows during movement. Debris flows normally occur when a landslide moves down slope as a semi-fluid mass scouring, or partially scouring soils from the slope along its path. Flows are typically rapidly moving and also tend to increase in volume as they scour out the channel.

3 Causes of landslides

A landslide is a complex dynamic system. An individual landslide characteristically involves many complex processes operating together. These are classified into intrinsic and extrinsic variables.
Intrinsic variables: Geology, slope gradient, slope aspect, elevation, soil geotechnical properties, vegetation cover, and long term drainage patterns are intrinsic variables that contribute to landslide susceptibility. The steeping of the slope, water content of the stratum and mineralogical composition and structural features, which tend to reduce the shearing strength of the rocks, are also vital factors.
Extrinsic variables: A slight variation or jerk to the mass, or a tremor would greatly add up against frictional resistance and the mass would become unstable. The heavy traffic in a hilly terrain could be a contributing factor towards causing the imbalance of the masses. The extrinsic variables may change over a very short time span, and are thus very difficult to estimate.

The main causal factors for slope failures can be divided into preparatory and triggering causal factors.
Preparatory factors: These are factors which make slopes susceptible to movement over time without actually initiating it — e.g., deforestation caused reduction in material strength; loose soil, rock and fragmented materials, bedding lineaments, faults, erosion of the slope toe due to streams or human activities, dam construction, loading of the slope at its crest such as construction on the top slope, soil of clayey or clayey loam which absorb considerable quantity of water etc.
Triggering factors: These are external stimuli responsible for the actual initiation of mass movements — e.g., earthquake, intense rainfall for a short duration on a weak plane or prolonged high precipitation, inconsiderate irrigation etc. (Knapen *et al.*, 2006; Ramachandra *et al.*, 2009).

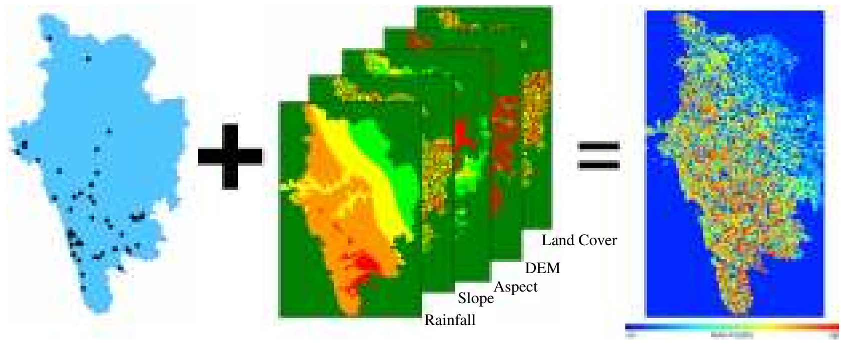

Figure 1. Methodology used for landslide prediction in openModeller.

4 Karwar landslides

On 2nd October, 2009, on an exceptionally high rainy day (423.6 mm recorded on 3rd morning) 21 landslides of varied intensities struck the coastal hills of Karwar towards the centre of Indian west coast. Karwar is a taluk in the Uttara Kannada district (formerly North Kanara) of coastal Karnataka and also the district headquarters (Figures 1 and 2 for topography and important landslide locations). Flanked by the Arabian Sea to the west, most of Uttara Kannada's low altitude (seldom exceeding 600 m) hilly terrain receives heavy monsoon downpour from 3000–5000 mm, confined to six or seven months. Waters rush down the rugged terrain and streams and rivers swell during the peak rainy period of June to September. Exceptionally October might get cloudbursts as well, otherwise receiving lesser rains seldom ever associated with floods. The district's north–eastern region, in the taluks of Mundgod and Haliyal, which merge with the drier Deccan receive rains less than 1600 mm, and are characterized by less rugged undulating terrain. Whereas tropical evergreen–semi-evergreen forests characterize the heavy rainfall region, moist to dry deciduous forests are natural to the lower rainfall areas. The coast itself, unlike rest of the South Indian west coast, is hilly in many places and interrupted by the mouths of five rivers and several small creeks. Steep rising hills, promontories of the Western Ghats, are notable of the physiography of the coastal Karwar town and its neighbourhood, that witnessed unprecedented floods and landslides in early October, 2009. The sprawling Kali River estuary with its several ramifications is notable feature of landscape between Karwar town and Goa territory border about 10 km to the north.

Horticultural gardens with arecanut, coconut, banana, pepper, cardamom, cocoa, vanilla etc. characterize partially shaded narrow valleys having perennial water supply. Rice, sugarcane, groundnut, vegetables etc. are grown in wider valleys and plains of the north–east and the coast. Fields of rice, jowar, sugarcane, chillies etc and mango orchards characterize the otherwise wooded landscape of Mundgod and Haliyal. Unlike anywhere else along the South Indian coast the Western Ghats come too close to the coast in Karwar, some of its promontories entering into the sea itself. The steep

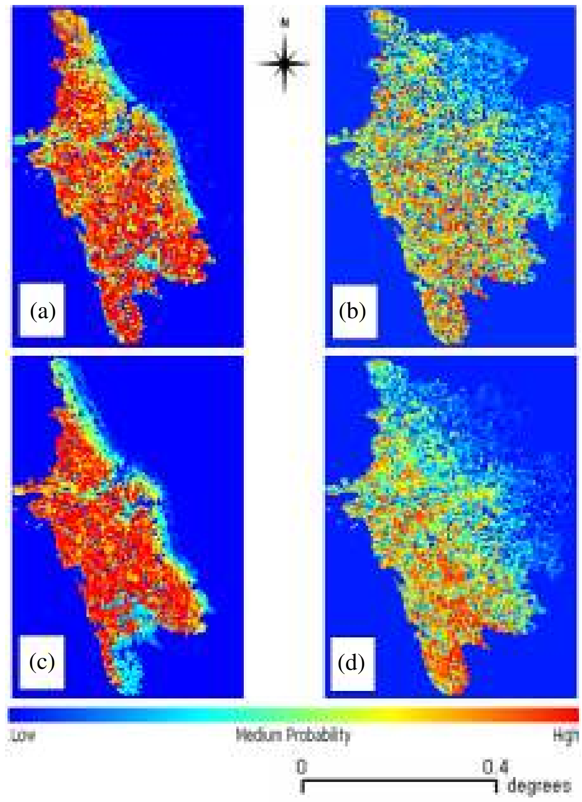

Figure 2. Probability distribution of the landslide prone areas.

escarpments of the Western Ghats form almost a semi-circle to the south, west, and far north of Karwar, closer to the Goa border. The National Highway-17 winds its way through the foothills and coastal alluvium, before entering the Karwar town, from where it passes northwards parallel to the beach. The Karwar port is situated towards the immediate south–west of the main town in the Karwar Bay. The fisheries port at Baitkol is close to the main port on the east of a 210 m high promontory of the Western Ghats. The INS Kadamba Naval Base occupies the narrow stretch of coastal strip from north of Ankola taluk to the south of the Karwar port. Many hills of heights from 300 to 500 m are present within few kilometers of Karwar town.

Locations of landslides: The 21 landslides of different magnitudes happened in the hills, most of them

Table 1. Landslide locations in Karwar taluk.

Slide location	Lat–Long	No. of slides	Approx. volume of slide material
Kadwad-1 (near Forest naka)	14°49′59.2″N–74°10′39.8″E	01	400,000 cu.m
Kadwad-2	14°52′40.2″N–74°10′47.6″E	01	750,000 cu.m
Arga (near NH-17)	14°46′51.2″N–14°46′58.9″N 74°08′29.2″E–74°08′47.3″E	04	70,000 cu.m
Baithkol (near port)	14°48′07.4″N–14°48′16.5″N 74°06′47.9″E–74°06′50.8″E	05	14°48′38.7″N–74°10′47.6″E 88,000 cum
Shirwad	14°48′38.7″N–74°10′47.6″E	01	100,000 cu.m
Mandralli	14°50′50.2″N–74°09′22.7″E	01	45,000 cu.m
Makeri Makeri	14°49′15.3″N–14°50′50.2″N 74°10′17.5″E–74°10′17.6″E	03	13,300 cu.m
Baad	14°48′14.5″N–14°48′25.1″N 74°08′13.2″E–74°08′22.4″E	02	8,000 cu.m
Binaga	14°46′53.9″N–14°47′27.9″N 74°06′53.5″E–74°08′10.0″E	03	37,000 cu.m

along the NH-17 and other roads (Figures 1 and 2 for important landslide locations). The densely populated town itself was lucky to have escaped from the damages of landslides but not from the flood fury. Some of the low hills that suffered landslides are in the villages bordering the south of the estuary in the villages of Kadwad, Makkeri and Mandralli. Habitations have sprung up along the toes of these low hills in these villages. But human casualties (19 deaths) happened only in Jariwada site (Kadwad-2). The locations of the landslides are given in the Table 1. The NH-17 was blocked in several places due to the landslides in Arga and Binaga. Some of these slides destroyed the compound wall of the Naval base to the west of the highway. The Baithkol fisheries port and main port areas together suffered 5 landslides; as all these happened just outside the densely populated hillsides the people had providential escape. Shirwad hill of 81 m, bordering the marshes had a landslide and roughly 100,000 cum material came out of it.

Jariwada (Kadwad-2) had the worst landslide in the history of Uttara Kannada district which buried alive 19 people, and destroyed several houses and property. The slide happened on a mound of 65 m, to the south of Kali estuary. The slide material volume of approximately 750,000 cu.m, traveled a distance of 300 m, burying people and destroying houses and entering the estuary, its further advance stopped by the Konkan Raliway embankment (Figures 3–5). Kadwad-1 slide happened in another mound of 78 m. About 400,000 cu.m of debris and soil travelled a distance of 300 m from the slide, crossing a road there wwas no human casualty from this slide (Mishra, 2009). Interaction of a variety of factors caused the landslides. Of these important are geological factors, excessive rainfall and anthropogenic pressures.

5 Geological factors

Landslides on lateritic hills: Coastal hills of Uttara Kannada broadly come under two categories. Hills which rise precipitously, most of them exceeding 200 m high,

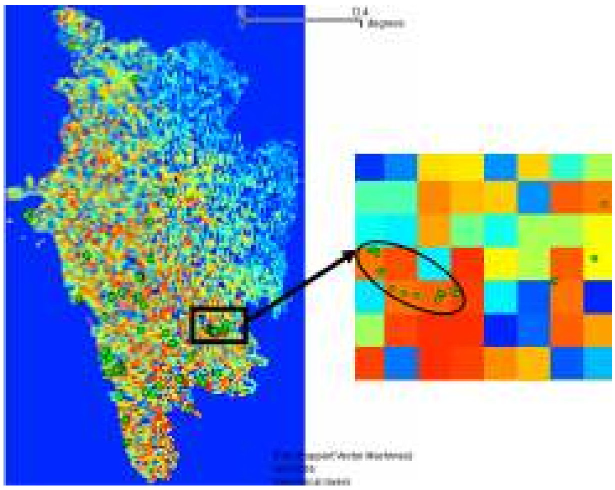

Figure 3. Validation of the probability distribution of the landslide prone areas by overlaying landslide occurrence points.

have granite as the main rock type. These hills characterize northern coastal stretches from Ankola to Karwar. Low lateritic, flat-topped hills and plateaus, not exceeding 100 m are feature of the southern coast of Kumta, Honavar and Bhatkal taluks. The main rock type of landslide hills in Karwar is granitic. However, some of the low hills bordering the Kali estuary are nothing but mounds of soil with laterised tops. The Kadwad hills (Kadwad-1 and 2) fall in this category. Such hills are not true hills of the Western Ghats but constituted of sedimentary soils deposited by archaic water courses that rushed down from the hills of Ghats. Forests of evergreen nature flourished once on these soil mounds, as their vestiges in a sacred grove at Kadwad-2 site indicate. Similar was the case with most other laterite topped low hills and plateaus of coastal Uttara Kannada. Shifting cultivation through ages and savannization for cattle grazing created much denudation of the coastal hills (Chandran, 1997).

An understanding of laterite formation is required to explain some of the Karwar landslides, especially

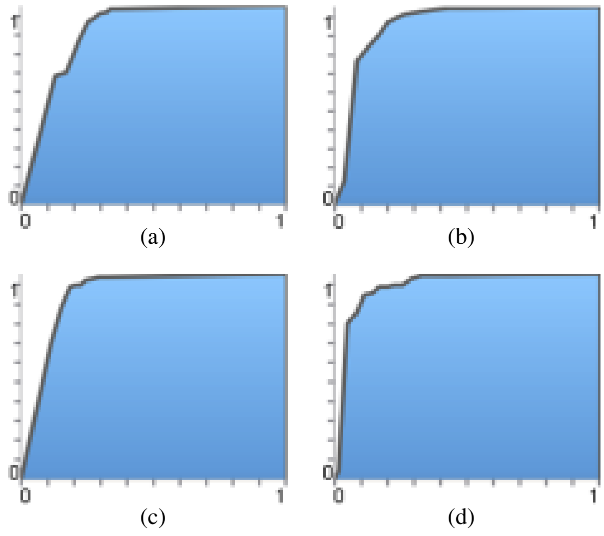

Figure 4. ROC curves for landslide prone maps (a) GARP (b) SVM on precipitation of wettest month; (c) GARP and (d) SVM on precipitation of wettest quarter.

Figure 5. Landslide occurrence points in Kerala.

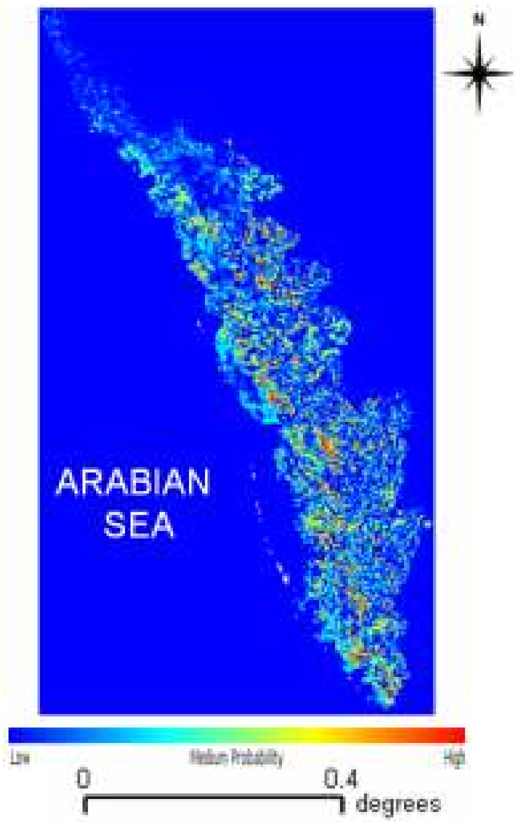

Figure 6. Probability distribution of the landslide prone areas in Kerala using precipitation in the wettest month data.

of Kadwad hills. Laterites are formed by the decomposition of rock, removal of the bases and silica and formation of oxides of iron and aluminium at the top of the soil profile. They are soft when wet but harden with age. Laterites are of two types. Primary laterite is found *in situ*. The original rock structures, joints and quartz material are in tact and the laterite deposit overlies the bedrock. Primary laterite is found at higher altitudes. The Indian south-west coast laterites are considered to be of secondary nature, being formed from sedimentary deposits such as gravels and pebbles by sesquioxide impregnation and cementation. They are pellet type and quite different from the underlying soil or bedrock. These laterites have a continuous softening effect with depth. The laterites are normally subjected to alternate wet and dry climates (Ranjan and Rao, 1991). Leaching down of soluble materials during rains and cementation of accumulated detritus, especially iron and aluminium, on exposure makes secondary laterites dry and hard. Denuded hills and plateaus covered with hardened and eroded surface laterite, with characteristic honey-combed structure, are characteristic of southern coast of Uttara Kannada. These hills are very stable, being covered with natural shields of iron rich laterite. The two hills at Kadwad, (Kadwad-1 of 78 m & Jariwada-Kadwad-2 of 65 m) exhibit only partial laterite formation towards the exposed top. Exposed indurated boulders with typical honey comb structure, characteristic of the southern hills of Uttara Kannada coast are scanty in the Kadwad hills. Laterisation process is incomplete iniside the hill also (Figure 6) mainly due to insufficient soil drainage due to the closeness of the estuary and the hills themselves being formed on palaeo river courses as springs exist in these hills to this day. 'Jariwada' in local language means hamlet situated on 'jari' or spring. Water table is high in the Kadwad village and it is expected also for the water to rise through the soil by capillary force from below. Soil samples from the bottom of Kadwad-2 showed 88.3% sand revealing its weak foundation. Such dampness in the interior of these clayey soils with high mix of sand especially towards the base would have been considerably aggravated by the heavy rains of late September and the first two days October. Water would have percolated through the thin mantle of laterite as well as through crown cracks developed on the hills, understandably due to swelling of the clayey soil in the interior.

The natural proneness of the weak structured Kadwad hills to landslides would have been aggravated by deforestation due to past shifting cultivation, hacking for biomass by the locals, ever-increasing toe cutting by locals for expansion of holdings, soil removal by some local contractors etc. The situation got worsened when the remaining natural vegetation was cleared some years ago by the Cashew Corporation for raising plantations, unaware of the fact that cashew would be a poor choice for covering fragile, landslide prone hills of soft clayey, water-logged soils. The stumps of the earlier trees, expectedly, underwent deterioration making hollows on hill surface facilitating increased rain water seepage into the interior of the hills and soil expansion probably causing the formation of crown cracks. The heavy rains ultimately triggered the disastrous slope failures during early October 2, 2009. Indeed, any coastal hills, with their bases moored in estuarine shores, if they are inadequately covered with natural vegetation and/or their sides cut for expansion of holdings or for soil, landslides are likely to happen. Such a slide occurred in the Holegadde village of Kumta taluk during the rainy season of 2010, but fortunately without any casualties.

Landslides on granitic hills: Granite is the main rock type in the slides that happened in 12 locations. Eight of these slides were along the hills adjoining the NH-17, viz. Arga (4 slides), Binaga (3 slides) and one opposite the Karwar commercial port. The entire western portion of these villages fall under the high security INS Kadamba Naval Base, the NH side wall of which was badly breached by landslides and storm waters, for which the wall acted like a dam that could not stand the force of the storm water. The debris in all these slides included granite boulders, cobbles and overburden of soil and weathered granite (Figure 8). Five slides happened in the hills towards the south and south-west of Karwar Port at Baithkol. In a slide that took place along the vertical slope of the hill (DC's residence hill) huge granite boulders came crashing down on the NH-17 and even crossed over it towards the Arabian Sea. Approximately 10,000 cu.m of debris moved down the slope and blocked the road. In the rest of the Baithkol slides, close to the fisheries port, the material consisted of boulders, cobbles of weathered granite and mafic dyke, laterite and lateritic soil (Mishra, 2009).

Shearing forces: On steep granitic slopes, inadequately covered with vegetation, heavy rains would have soaked up the overburden of soil and fractured rocks activating shearing forces. Cutting deep swathes in the hills for expansion of holdings, highways and other roads as well as for soil removal would have also activated shear forces. Since laterite is missing at many places, there is no continuity between rocks and soil, and hence water lubricates the contact between rocks and soil/weathered debris thereby increasing shearing forces (Hegde, 2009).

6 Triggering factors

Rainfall: Slope instability due to rainfall is a common geotechnical problem in tropical and subtropical areas. Infiltration of rain water into a slope decreases slope stability. When water starts to infiltrate the unsaturated soil the negative pore-water pressure builds up turning into the mechanism that causes slope failures (Gasmo *et al.*, 2000; Tsaparas *et al.*, 2001). Slope failures in the tropical regions like Malaysia are commonly triggered by frequent rainfall (Lee *et al.*, 2009). Deforestation on steep slopes by logging or fires have increased debris-flow frequency (DeGraff, 1991; Guthrie, 2002). Analysis by Dahal and Hasegawa (2008) of 193 landslides in the Himalayan locations showed that when the daily precipitation exceeded 144 mm, the risk of landslides was high. All the 21 landslides in Karwar occurred on 2nd October, 2009, the most fatal of them at Jariwada in Kadwad, between 4–4.30 pm. By the morning of October 2, Karwar had already received 3,370 mm of rainfall for the season. That fateful day, when all the slides are stated to have happened, Karwar experienced a very heavy spell of rains exceeding 400 mm (423.06 mm recorded in the morning of October, 3rd).

Recurrence of heavy rainfall: As the hill slopes of coastal Karwar remain heavily deforested slope failures could happen on any day of incessant rains, the threshold for this important triggering factor will depend on the previous rainfall during the season, the state of tree cover in the hills and the degree of slope. A look at the daily rainfall history of Karwar for the 1994–2009 period (Figure 7) shows that heavy rainfall (>200 mm a day) events happen periodically. If the site-specific threshold value is crossed the landslides could happen on any day in vulnerable slopes. October 2, 2009 episodes of 21 landslides indicate that on the recurrence of similar events slope failures are likely to return.

Deforestation and landslides: The heavy annual rainfall of over 3,000 mm at Karwar is sufficient to create an evergreen forest of high biomass. Given moderate amount of human pressures happening today as in many of slightly more interior parts of Karwar taluk, in rest of the forests, even on more precipitous slopes, hardly had any landslides taken place in the past. These inner coastal forests normally have denser tree growth and basal area of 30–40 sq.m/ha. Same is the situation in most of Uttara Kannada which has hardly any history of fatal landslides. It is well known fact that good forest cover on hills is some kind of security from landslides and flash floods. Abe and Ziemer (1990) state that forest vegetation, especially tree roots can extend into joints and fractures in the bedrock or into a weathered transitional layer between the soil and bedrock. The stabilization of slopes by vegetation depends on the depth to which the roots grow. The more the roots penetrate a potential shear plane, the greater is the chance that the vegetation will increase slope stability. Rooting strength is important factor in cohesion of substratum. Forest vegetation can potentially attenuate downstream effects of landslides. If the slope vegetation is clear-felled the

Table 2. Vegetation composition.

Study locality	Estimated trees/ha	Estimated basal area/ha (sq.m)	% evergreen trees	Mean ht (m)
Kadwad-2	76	2.356	3	3.8
Arga hill	44	5.92	20	5.9
Amdalli hill	435	26.84	87	10

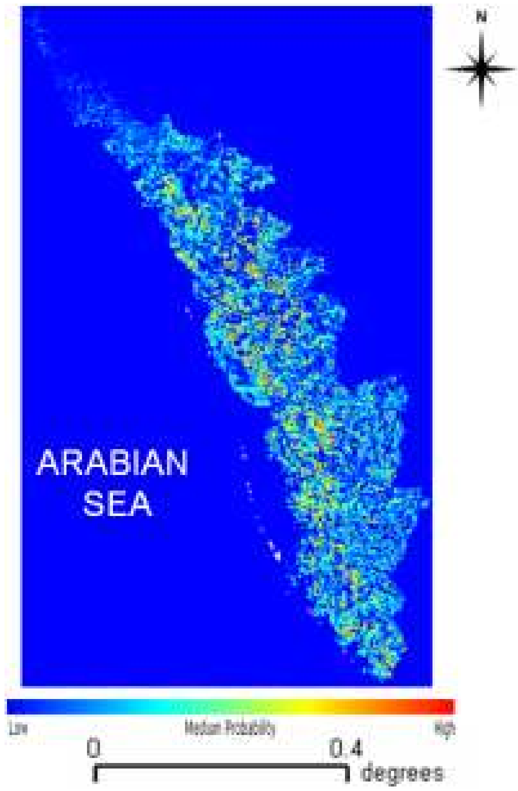

Figure 7. Probability distribution of the landslide prone areas in Kerala using precipitation in the wettest quarter data.

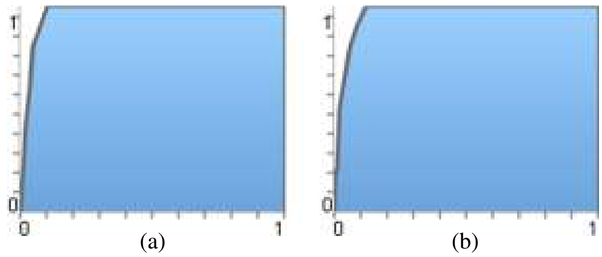

Figure 8. ROC curves for the predicted landslide prone maps of Kerala. (a) using precipitation of the wettest month, (b) using precipitation of the wettest quarter.

probability of landslides occurring will increase, particularly after a few years when the roots are decomposed and loose their stabilizing force. According to Bruijnzeel (2004), whereas a well developed tree cover can prevent shallow landslides up to about 1 m depth, deep landslides of >3 m are not appreciably affected by forest cover. In cases of extreme climate events such as hurricanes, trees may actually increase slope instability due to the tree weight and the susceptibility of particularly high trees to uprooting due to extreme storms, damaging the soil matrix. Thousands of landslides occur in the Himalayas every year. On an average, nearly 200 earthquakes of smaller magnitude, most of them undetected by local communities, occur every year in the Uttarakhand region alone. According to VC Thakur, former Director of Wadia Institute of Himalayan Geology, the uncontrolled downhill flow of water after heavy rains, particularly along barren slopes, was an important causative factor in these landslides. A study conducted in 1984 on the relationship between the building of the Mussoorie–Tehri road and landslides revealed that landslides caused more devastation in deforested rather than forested areas (Kazmi, 1998).

Too poor and human impacted vegetation: We selected three localities for vegetational study in the coastal hills of Karwar, two of them in the landslide affected hills (Kadwad and Arga) and the third one in Amdalli, on a steep rising coastal granitic hill, of over 300 m abutting on the NH-17, which has somewhat lesser human pressure, and where landslides have not happened, despite having experienced almost similar rainfall conditions as the rest of coastal Karwar. All the hills had, presumably, a history of shifting cultivation during the pre and early colonial period, at least towards the latter half of the 19th century, as per ecological history of the region and as revealed by nature of the present day vegetation and eroded soil surfaces. Some of the elderly residents of Kadwad-2 site also referred to the hill as bearing the name *kumri-jaga* (shifting cultivation locality), and Kunbis (former shifting cultivators) once resided in the village. The passage of over one century after last of shifting cultivation episodes would have facilitated forest succession leading towards reasonably good semi-evergreen forests in all the hills. However, due to increased pressure from growing population, for meeting their biomass needs the British declared the forests of most coastal hills as ‘minor forests’ which eventually suffered from over-exploitation of resources. Remains of a sacred grove towards the base of the hill has few large forest trees such as *Mammea suriga, Mimusops elengi, Mangifera indica* and *Sterculia guttata*. The vegetation analysis of the three sample sites is given in the Table 2.

Some decades ago the Kadwad hills (the sites of two major landslides) were stripped of natural vegetation; in Kadwad-2, 20 hectares were planted with cashew. Uncared for subsequently the hill has neither good cashew trees nor any other native species. The trees were sparse and stunted with a density of just 76/ha; it could have been at least 350/ha, more of evergreen nature, and the basal area maintained at a minimum of 30 sq. m/ha, considering the fragile geology. The present basal area of 3.8 sq.m/ha, is too low to offer any slope stability. The cashew is a shallow rooted tree to offer any slope stability. The Arga hill was having dense growth of weeds and scrub and trees were sparse and the basal area too low at 5.9 sq.m/ha. Amdalli hill, which did not undergo any landslide, and considered a control, had much higher tree number at 435/ha. The basal area of 26.84 sq.m/ha is still short of the desired 30 sq.m/ha. Moreover the trees were mostly undersized in height and girth as they were subjected to constant hacking. Most of the species were of secondary nature; yet basically multi-strata evergreen vegetation, ideal for soil and slope persisted. Most of the landslide hills had impenetrable tangle of weeds and creepers and thorny bushes, all shallow rooted. The entire coastal hillscape of coastal Karwar is fragile and calls for urgent attention as to the restoration of ideal ecological conditions leading to greater stability in the region.

Alterations in slope angle: According to Mishra (2009) the original slope angle of Jariwada hill of Kadwad was very low at $\sim 20^{\circ}$, prior to human interference. The modification of the slope by cutting 15–20 m vertical slope (as observed in the right and left flanks of the slide zone of 60 m width and 30 m depth) for human settlement and plantation increased instability. In Kadwad-1, which had a 100 m width slide, of 15–20m depth, there was a vertical cut of 10 m height near the toe. The slope was cut for road formation. There was also excavation at the mid-slope to flatten the slope. The toe cutting and removal of material from the site has increased the driving force. As the slope forming material is mostly lateritic soil, clayey soil and overburden, the over-saturation of the slope material decreased the resisting force. Similar toe cutting, mostly for road making, happened almost in all the studied landslide locations. The original slope angles were gentle with a very low relief.

Land use changes: The clearances of natural vegetation for planting cashew apparently became an important cause for landslide in the Kadwad hills, so too expansion of household gardens into the hill by slope cutting. Slope cutting for road formation was common cause wherever landslides happened. There has been heavy colonization of humans in the Baithkol fisheries port area, causing rampant toe cutting of the isolated, steep sided 210 m tall hill protruding into the Arabian Sea from the south of the Karwar Bay.

Improper drainage: Natural drainage of rainwater has been affected in the slide areas due to different reasons. In the Kadwad hills the water table is high due to the nearness of the estuary and the hills being ancient mounds of soil in the way of a palaeo-river course descending from the Western Ghats. Over-saturation of soils during heavy rains is a constant factor here. Blockage of natural drainage, increasing the overburden saturation during heavy rains has been considered a potent reason for the landslides in Arga and Binaga hills. The high rising compound wall of INS Kadamba Naval Base acted like a dam impeding storm water drainage; the wall itself crumbled in few places due to the rush of storm water and slide material of stones and soil.

Stone quarrying and soil removal: In Zariwada there was reported excavation of soil in front of the slope that failed for the construction of the Konkan Railway embankment, increasing vertical slope height, inducing slope instability due to the volume and weight of material above the toe (Mishra, 2009). Granite quarries in the hills adjoining NH-17 would have also destabilized the hill sides as rocks came tumbling down from near a quarry site towards the highway and damaging the wall of the naval base.

Table 3. Confusion Matrix Structure.

	True presence	True absence
Predicted presence	A	B
Predicted absence	C	D

Key: A – True Positive, B – False Positive, C – False Negative, D – True Negative.

7 Landslide susceptible location prediction through openmodeller

This study use pattern recognition techniques such as Genetic Algorithm for Rule-set Prediction and Support Vector Machine based models to predict the probable distribution of landslide occurrence points based on several environmental layers along with the known points of occurrence of landslides. The model utilises precipitation and six site factors including aspect, DEM, flow accumulation, flow direction, slope, land cover, compound topographic index and historical landslide occurrence points. Both precipitation in the wettest month and precipitation in the wettest quarter of the year were considered separately to analyse the effect of rainfall on hill slope failure for generating scenarios to predict landslides (Ramachandra *et al.*, 2010).

A free and open source software — openModeller was used for predicting the probable landslide areas. openModeller (http://openmodeller.sourceforge.net/) is a flexible, user friendly, cross-platform environment where the entire process of conducting a fundamental niche modeling experiment can be carried out. It includes facilities for reading landslide occurrence and environmental data, selection of environmental layers on which the model should be based, creating a fundamental niche model and projecting the model into an environmental scenario using a number of algorithms as shown in Figure 1.

Two different precipitation layers were used to predict landslides — precipitation of wettest month and precipitation in the wettest quarter of the year along with the seven other layers. Figure 2(a) and (b) are the landslide probability maps using GARP and SVM on precipitation of wettest month. The landslide occurrence points were overlaid on the probability maps to validate the prediction as shown in Figure 3. The GARP map had an accuracy of 92% and SVM map was 96% accurate with respect to the ground and Kappa values 0.8733 and 0.9083 respectively. The corresponding ROC curves are shown in Figure 3(a) and (b). Total area under curve (AUC) for Figure 4(a) is 0.87 and for Figure 4(b) is 0.93. Figure 4(c) and (d) are the landslide probability maps

Table 4. Confusion matrix for GARP and SVM Outputs for Uttara Kannada.

Uttara Kannada		True presence	True absence	Number of usable presence	Number of usable absence
GARP with precipitation of wettest month	**Predicted presence**	120	0	125	0
	Predicted absence	5	0		
SVM with precipitation of wettest month	**Predicted presence**	118	0	125	0
	Predicted presence	7	0		
GARP with precipitation of wettest Quarter	**Predicted presence**	118	0	125	0
	Predicted presence	7	0		
SVM with precipitation of wettest Quarter	**Predicted presence**	117	0	125	0
	Predicted presence	8	0		

using GARP and SVM on precipitation of wettest quarter with accuracy of 91% and 94% and Kappa values of 0.9014 and 0.9387 respectively.

ROC curves in Figure 4(c) and (d) show AUC as 0.90 and 0.94. Various measures of accuracy were used to assess the outputs. Table 3 presents the confusion matrix structure indicating true positives, false positives, false negatives and true negatives.

Confusion matrices were generated for each of the 4 outputs (Table 4) and different measures of accuracy such as prevalence, global diagnostic power, correct classification rate, sensitivity, specificity, omission and commission error were computed as listed in Table 5. The results indicate that the output obtained from SVM using precipitation of the wettest month was best among the 4 scenarios. It maybe noted that the outputs from GARP for both the wettest precipitation month and quarter are close to the SVM in term of accuracy. One reason is that, most of the areas have been predicted as probable landslide prone zones (indicated in red in Figure 2(a) and (c)) and the terrain is highly undulating with steep slopes that are frequently exposed to landslides induced by rainfall. Obviously, the maximum number of landslide points occurring in the undulating terrain, collected from the ground will fall in those areas indicating that they are more susceptible to landslides compared to north–eastern part of the district which has relatively flat terrain.

Another case study of Kerala state, India was carried out with the same environmental layers along with 10 landslide occurrence points as shown in Figure 5. The predicted output for precipitation in the wettest month is shown in Figure 6 and precipitation in the wettest quarter is shown in Figure 7 with an overall accuracy of 60%. The Kappa values for two cases were 0.966335 and 0.96532. The ROC curves are shown in Figures 8(a) and (b) with 0.97.

8 Prevention and management

Several ways of prevention and management, many with general applicability and the others of site specific nature, are employed worldwide. Here only ecologically compatible non-engineering measures have been dealt with.

Identification of landslide prone areas: Based on soil and rock structure, rainfall patterns, slope and vegetation characteristics (evergreen, deciduous, scrub, plantations, fields, gardens etc.) and human impacts, preparation of landslide hazard zonation maps at 1:1000 scale are essential. The methodology has been already evolved by the Department of Science and Technology, Government of India, under the Natural Resources Data Management System.

Drainage correction: In the hilly areas natural drainage patterns should be studied and maintained properly without any blockage. Characteristic stream-side species are to be promoted for stream-bank protection and ecology.

Restoration of vegetation cover: A replanting programme should be undertaken giving priority for strong and deep rooted species which check erosion and withstand water-logging. *Pongamia pinnata, Calophyllum inophyllum, Ficus racemes, Thespesia populnea, Barringtonia* spp., *Terminalia arjuna* etc. may be considered for lower slopes bordering the estuarine areas. Middle and upper slopes in landslide prone areas should be planted with tree having lower biomass but stronger and deeper root networks. High biomass trees are likely to cause the weight of the overburden precipitating slope failures in future. Minimum of 350 trees/ha would be ideal number for the hills. Locality-specific members of the natural vegetation of any given area may be given priority. The general practice of monoculturing of trees has to be discontinued in all hazard zones

Enhancing the scope of VFCs: The scope of the already existing village forest committees may be expanded to

Table 5. Statistics of GARP and SVM Outputs for Uttara Kannada.

Uttara Kannada	Prevalence (A+C)/N	Global diagnostic power (B+D)/N	Correct classification rate (A+D)/N	Sensitivity A/(A+C)	Specificity D/(B+D)	Omission error C/(A+C)	Commision error B/(B+D)
GARP with precipitation of wettest month	–	–	0.96	0.96	–	0.04	–
SVM with precipitation of wettest month	–	–	0.94	0.94	–	0.06	–
GARP with precipitation of wettest Quarter	–	–	0.94	0.94	–	0.06	–
SVM with precipitation of wettest Quarter	–	–	0.94	0.94	–	0.06	–

* Key: A – True Positive, B – False Positive, C – False Negative, D – True Negative, N – Number of Samples.

landslide/natural resource management as well. Necessary awareness and training programmes may be arranged for them in landslide prevention and management.

Regulations on slope cutting and quarrying: Indiscriminate slope cuttings have to be strictly regulated and engineering solutions such as protective walls/embankments to be made where they are essential. Bio-protection is by far most important. Quarrying for stones and soils to be strictly limited to specified localities which pose no threat of landslides.

Development to be limited to carrying capacity: Karwar with several major projects such as India's largest naval base, Kaiga Atomic Plant, commercial port and a fisheries port, offices and several more establishments appears to be transgressing its ecological carrying capacity. The authors are presently engaged in a project estimating the ecological carrying capacity of Uttara Kannada district, and are expected to formulate specific measures for safeguarding ecological stability of the region as well as recommend developmental projects that are compatible with the rich biodiversity and ecological fragility of the region.

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Disaster risk management in chemical industries — A case study

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ABSTRACT

There have been considerable changes with respect to the frequency and intensities of natural hazards. The impact of these natural hazards on the chemical industries handling highly hazardous chemicals is significantly high and has the potential for '**combination accidents**' for example, triggering of chemical disaster, fire disaster etc. due to flood/earthquake disaster. The consequences of such disasters are very severe, both in terms of financial losses and safety of employees & public. In view of the above, the disaster management in hazardous chemical industries has become of significant importance. The paper highlights the consequences of floods and the precautions to be observed in case of flood emergency in a chemical industry with a case study of a flood incident at Ammonia based chemical plant at Hazira, Surat. The safety issues that surfaced from the review of the incident and the mitigation measures have been highlighted. The paper also suggests the application of 'Risk Assessment Techniques' for identifying hazards from such natural hazards triggering industrial hazards and incorporating mitigation measures in design stage, thereby aiding in formulating effective and efficient 'Disaster Management Plan'.

1 Introduction

In today's global scenario, natural disasters are perceived to be on rise both in magnitude and frequency and the same holds true to our Indian scenario. Over the past decade, the number of natural and manmade disasters has climbed significantly. As per the global data on reported disasters figure (from 1999–2003) it is seen that there were 707 disasters events per year showing an increase of about 60 per cent over the previous years. These natural disasters have domino effect on the industrial facilities (housing hazardous chemicals, gas & oil inventories, port terminals, power plants, transportation of dangerous materials), triggering technology malfunctions, which may result into release of hazardous materials disasters, hazardous wastes, fires disasters etc. The consequences of these 'combination accidents' are very high, causing huge damage to public and environment as a whole. In our own Indian context, the above combination accidents have been witnessed umpteen numbers of times. The Gujarat Cyclone in the year 1998 affecting industrial heart of Gujarat, Super Cyclone in the year 1999 affecting major industries located in Orissa coastal belt, major earthquake in Kutch district in the state of Gujarat in the year 2001 affecting the ports & major industries, Tsunami waves affecting approximately 2260 km coastal length of India in the states of Tamil Nadu, Andhra Pradesh, Andaman & Nicobar Islands etc. in the year 2004 are some of the examples. In India, 59 per cent of the land mass is susceptible to seismic hazard; 5 per cent of the total geographical area is prone to floods and 8 per cent of total landmass is prone to cyclones.

The changes in the climate witnessed in the recent years has its own share of damages and triggering technological accidents like increase in incidents of floods due to changes in rainfall pattern and carrying capacities of rivers, forest fires etc. Flooding causes severe disruptions in environment due to release of chemicals stored above ground, release of toxic wastes from waste treatment plant, contamination of drinking water, disruptions in sewage treatment facilities, triggering of fire/explosions due to loss of process control, reactions between hazardous & pyrophoric chemicals and flood water, electrical system mishaps and so on. In view of this increased probability of natural disaster triggering a chemical disaster, as a conservative approach, it has become necessary to consider the same as *worst-case scenario* during preparing 'Disaster Management Plan' for particular plant site.

The paper highlights the *case study* of a flood incident at a Chemical Plant located at Surat, Hazira Industrial belt in Gujarat state and the application of the 'Disaster Risk Management Plan'. The plant falls under the purview of the Atomic Energy Regulatory Board (AERB). The safety issues that surfaced from the flood incident were reviewed in detail by AERB and certain recommendations were made to improve the emergency response plan due to such incidents. The paper also highlights the significance of 'Risk Assessment' techniques in design stage considering both natural and human induced postulating events triggering a disaster.

2 Understanding the fundamentals of disaster & disaster risk management

Disaster means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk. Disaster occurs only when hazards and vulnerability meet.

Disaster management cycle: Disaster risk management includes sum total of all activities, programme and measures mainly preparedness and mitigation, which can be taken up before, during and after a disaster with the purpose to avoid from its losses. The key stages of activities that are taken up within disaster risk management are,

(1) *Before a disaster (pre-disaster):* Activities taken to reduce human and property losses caused by a potential hazard. These are mitigation and preparedness activities.

(2) *During a disaster (disaster occurrence):* Initiatives taken to ensure that the needs and provisions of victims are met and suffering is minimized. These are emergency response activities.

(3) *After a disaster (post-disaster):* Initiatives taken in response to a disaster with a purpose to achieve early recovery and rehabilitation of affected communities, immediately after a disaster strikes.

The following case study of the above mentioned chemical plant handling hazardous substances at high temperatures and pressures and embraced with a flood hazard would enlighten the application of these fundamentals.

3 Case study

3.1 Incident narration

The chemical plant covered under the case study is located on the bank of river TAPI about 15 km from Surat city within the fertilizer complex. The plant handles large quantities of ammonia, Synthesis gas and potassium amide at very high pressure and temperature. The plant also has inventory in small quantity of hazardous materials like hexane, potassium metal, natural gas/naphtha and various industrial chemicals. Some of the chemicals like potassium amide, potassium metal react violently when in contact with water.

River TAPI originates from Betul in the Satpura Hills of Madhya Pradesh and flows through Maharashtra & Gujarat. A dam was constructed at UKAI, which is 80 kms upstream of Surat Hazira industrial belt, with the sole aim of avoiding flood. It has been noticed that the water carrying capacity of the TAPI river has reduced considerably over the years; the reason is continuous deposition of topsoil and sewage. The frequency of flood in Surat city has increased due to reduced water discharge capacity of the river (upto 5 lakh cusecs).

On August 07,2006, Surat city in Gujarat, nearby villages and the industrial belt of Hazira faced the disaster situation due to flood, resulting from the release of large quantity of water from UKAI dam. The release of water continued and the plant mentioned & nearby villages remained submerged in water ranging up to 5 to 6 feet deep for four days. *The design basis flood level, considered during the plant design was based on historical data of highest flood level, which was around 1 feet. However, this was the highest flood level in the plant till date.*

The plant personnel had prior information about huge release of water from UKAI dam into the TAPI river since morning of the day of the incident and there was well an established communication between the plant, district collector office and UKAI dam authorities. Based on the information received by the UKAI dam authorities about release of water from the dam, decision was taken to stop the plant, incase water enters the plant premises. However, at 23.20 hrs the plant tripped due to electrical supply failure (due to ingress of floodwater into the substation) and the shutdown activities were completed by 00:00 hrs. At 01:30 hrs shift engineer observed that floodwater had entered into plant area through storm water drains and it was informed that water has also entered the residential colony (which raised upto 7 feet by afternoon of August 8, 2009). By next day water level in the plant premises was significantly high and continued for next three days due to continuous discharge of water from the dam (at a rate greater than 11 Cusecs) for three days. The communication system (including mobile phones) failed totally. The plant personnel were struck at respective places in the plant, as there was no facility to move through the floodwater. There was absolutely no communication within the plant and outside.

3.2 Actions initiated by plant personnel

The detailed activities with respect to the flood and the potential chemical disaster management carried out by the said plant are mentioned below.

Activities done during Pre-Disaster (i.e. before the ingress of flood water into plant premises): In view of information about the release of water from Ukai dam, plant had carried out certain mitigation and preparedness activities which reduced the human & property looses namely,

- It was ensured that *adequate manpower was available for taking safe shutdown* of the plant and the personnel are located at safe elevation in the control room after carrying out the required shutdown activities.
- The hazardous chemicals which *could react violently when in contact with water*, were shifted at higher elevations.
- The trip logic shutdown system for process control & safe start-up and shutdown were *ensured for healthiness for safe shutdown of plant in 'Auto' mode*.
- Two numbers of *emergency lights* were kept charged and in ready condition.
- Arrangements were made for *food packets*, biscuits and drinking water for the shift personnel.
- *Adequate isolation valve handles* were provided to the field operators for closing certain isolation valves during emergency.
- The *breathing air apparatus* and fire extinguishers were kept in the control room and fire station at higher elevations.
- The *communication system was checked* and deficiencies rectified.
- The rotating equipment tripped on electrical supply failure and *diesel generator set started on auto 'mode'* for providing electrical power to safety related critical equipment were verified.
- The *isolation of high-pressure loops* (HP) from low-pressure loops (LP) was done through the program matrix logic, monitored through the distributed control system (DCS) with the *available un-interrupted power supply* (UPS) and the loops kept pressurized by synthesis gas *as per standard operating procedure* (SOP).
- Shutdown of Crackers (for cracking ammonia gas into synthesis gas) was done as per SOP and cooling was completed.
- *Battery limit isolation valves* of natural gas line, steam etc was isolated manually.
- The UPS supply to field control panels, electrical supply to MCC panels and the diesel generator power supply was cutoff and diesel driven firewater pump was stopped.

During a disaster (ie. after the flood water entered the plant premises): There were certain lapses with respect to the emergency response activities namely,

- There was *total loss of communication system* both within and outside plant premises.
- Due to rise in water level, there was *no mobility of plant personnel* and other rescue teams identified during plant emergencies.
- The food supply to the personnel stationed on first floor of control room was hindered due to flood water level and observance of large numbers of venomous reptiles.
- There was *no drinking water supply*.
- Muddy water had entered the ground floor of the control room.

Post flood scenario: The floodwater started receding after three days. The senior plant personnel could make an entry into the plant premises and the shift personnel who were inside the plant for three days could be relieved from duties. There were *no casualties due to the flood disaster* however; there was loss of property due to damage of equipment like pump motors, diesel generator set and the Distributed Control System (DCS) bus isolation card.

The motors were decoupled, cleaned thoroughly, applied with varnish coat and the bearings replaced. The DCS electronic cards were cleaned, dried thoroughly and installed back. Certain activities were done at war foot to restore drinking water supply to plant and residential colony, electricity and establish communication systems. The instrument loop & trip logic simulation test was done to check for instrumentation communication and functioning as per design intent.

3.3 Review of the incident carried out by AERB

A review was carried out by AERB of the above-mentioned significant event both from 'Disaster Management' point of view and the safety aspects after restoration & start up of the plant. It was observed that due to real time information from the UKAI dam officials, availability of documented standard operating procedures to handle plant emergencies and the involvement of trained & experienced manpower, the plant was safely shutdown before the entry of floodwater within the premises. The pre-planning ensured that the hazardous chemicals & critical equipment were shifted to higher elevations, thereby preventing any ***combination accident***.

Certain safety issues related to the emergency response activities were observed, both with respect to preparedness and mitigation during the flood. It was noted that flood incident had occurred in this Hazira Surat industrial site in the year 1998. In view of the increased frequency of flood hazard, AERB recommended certain measures for improving 'Disaster Risk Management' due to flood hazards. Some of the significant recommendations are mentioned below.

(i) Procurement and maintaining two numbers of *motor operated boats* in the Fire & safety department for effective & efficient rescue of plant & residential township personnel during flood situations.

(ii) The control room should be equipped with *life jackets/air bag* to ensure plant safety by timely shutdown of plant and rescue of the control room personnel.

(iii) Openings should be made at suitable locations in the Control Room for draining the stagnated floodwater from the cable trenches.

(iv) Portable diesel operated pumps should be made available for dewatering the floodwater.

(v) The control room should be provided with proper access to the roof top for shifting personnel to safer location in case flood water level rises more than 6 feet.

(vi) Adequate emergency searchlights should be made available (at least 4 numbers) for proper mobility in plant area during total black out (no electrical power supply from any means).

(vii) Plant should ensure availability of portable diesel generator sets of suitable rating to meet the requirement for recharging walkie talkie (wireless communication sets) sets and portable illumination devices during such emergencies.

(viii) Plant should explore the possibility of constructing storeroom above fire station control room for storing the emergency and life saving equipment during such incidents.

(ix) A water tank with capacity of 5000 litres should be installed for catering the drinking water requirements of plant and the residential personnel.

(x) The height of dyke wall of fire pump house should be raised keeping the reference of highest flood level in the plant area.

It was recommended to mark the 'Reference Flood Level' of the plant site (based on the recent flood incident) for initiating planned safe shutdown of the plant. The marked flood level is now documented in the site emergency preparedness plan and the technical specifications for operation of the plant.

A 'Disaster Management Plan' for flood emergency has been prepared by fertilser unit clearly defining the precautions to be observed to be in case of flood emergency, major actions to be taken during flood emergency and after the flood emergency by various departments in plants like Personnel & Administration department, medical department, production department, mechanical, electrical, instrumentation, civil, fire & safety, laboratory and materials departments. The document clearly defines the role of each department before the flood incident, during the flood incident and post flood incident. The plant has implemented the recommendations and with the thoughtfully prepared 'Disaster Management Plan', the plant is prepared to mitigate any challenge due to flood hazard.

4 Role of risk assessment in disaster management plan

It should be noted that the hazards in a chemical industries are generally identified during the design stage by various methods for hazard identification such as safety review, 'checklist analysis', 'what — if analysis', 'fault tree analysis' and the commonly used technique of 'Hazard and Operability studies (HAZOP)'. Based on the risk analysis of the identified hazards and considering **design basis accidents**, one can postulate the set of accidents and take care of these accidents in design itself. During hazard identification, due consideration should be given to **postulated initiating events** due to natural disasters (based on historical meteorological data, hydrological aspects, geology & geo-technological aspects, seismicity aspects) and the identified hazards should be mitigated through adoption of safer engineering practices, improved safety devices and designing fail proof system.

The **design basis values for natural hazards** like earthquake, floods, cyclones, Tsunami etc. can be estimated for site-specific cases with historical data or determined through various national codes on design of structures. By considering the conservative design basis values for these natural hazards during site selection, design stages and construction stage, the risk due to the natural hazards could be reduced significantly.

Safety design bases (SDB) developed on safety based concept shall be adopted in all the stages of engineering of safety related civil engineering structures. In the safety based concept possible design and operational events (both for normal and abnormal conditions) are first postulated. The engineering is then carried out to ensure that the structural system is reliable and is competent to withstand or mitigate the consequences of these postulated conditions and thereby preventing disaster.

In-spite of the advances made in knowledge and technology, failure-free design and devices have remained elusive. Even the well designed and inherently safe chemical facility must prepare to control potentially hazardous events that are caused by human or mechanical failure, or by natural forces such as floods or earthquakes. An effective 'Disaster Risk Management Plan', integrating the potential chemical/industrial hazards with the integrated community emergency plan with respect to natural hazards, is a need for a hazardous industry and involves challenge. It's very important to know the fundamentals of disaster and disaster risk management to address the complex issues of potential for combination accidents.

5 Conclusions

Disaster Management in the Chemical Process Industries is an integral and essential part of a loss prevention strategy. An effective Disaster Risk Management Plan, with an integrated approach addressing combination accidents is a need for a hazardous industry. A good communication system, training & understanding of emergency procedures, regular interaction between government agencies & industries and a high level of availability of emergency equipment are the key areas for effective disaster management. The consequences due to natural disaster triggering technological accidents can be reduced adequately by detailed risk assessment, review of postulated initiating events during siting & design stages and taking safety into consideration as an element of the overall design process during civil engineering design and construction stage.

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Creating an empirically derived community resilience index for disaster prone area: A case study from Orissa

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ABSTRACT

'Resilience can be understood as Capacity to absorb stress or destructive forces through resistance or adaptation, the capacity to manage, or maintain certain basic functions and structures, during disastrous events, the capacity to recover or 'bounce back' after an event (Twigg, 2007). 'Resilience' is generally seen as a broader concept than 'capacity' because it goes beyond the specific behavior, strategies and measures for risk reduction and management that are normally understood as capacities. However, it is difficult to separate the concepts clearly. In everyday usage, 'capacity' and 'coping capacity' often mean the same as 'resilience"

The state of Orissa is located in the eastern coast of India at 17° 49′N to 22° 34′N Latitude & 81° 29′E to 87° 29′E Longitude. The state is divided into five morphological units: Mountainous and Highlands Region, Coastal Plains, Western Rolling Uplands, Central Plateaus and Flood Plains. It has been found out that the state is hub of disasters. The state was recurrently victimized by climatic chaos (floods, droughts, flash flood, cyclone, heat wave, high risk zone for earth quake & lightning) causing people more vulnerable and pushing state development more backward. Magnitude of poverty, hunger, trafficking, distress migration followed by social exclusion has widened the development gap many fold, despite the presence of rich resource base.

In this context, there is an increasing need to identify which community characteristics are most resilient to disasters. This research paper proposes method to quantify community resilience. The factor analysis method results in a weighted additive index model of 9 variables to derive district wise community resilience. These variables are from five capital groups namely Social Capital, Economic Capital, Human Capital, Physical Capital and Natural Capital. For this purpose, data related to Rural School, Health Center, Par capital income, Percentage of above Poverty Line Families, Educational attainment of the population, which can be measured by the number of years of formal schooling of the average person, People having concrete House, Road density, Forest cover and Access to safe drinking water are taken.

This study represents a preliminary attempt in quantifying community resilience. It outlines the method that can be used to define resilience index and offers a general guideline about the variables that might contribute to a communities' ability to recover from a disaster. The 30 districts of Orissa is ranked according to the score and categorises the districts into five groups i.e. least, low, moderately, high and highly resilient.

1 Introduction

Over the last century human beings have been over exploiting the earth resources for the sake of its comfort, which leads to generation of waste infusing the environment in many dimensions thus resulting in many changes in the earth. The recently observed climate change and the frequent natural disaster is an indicator of this change. Previously many attempts have been made to manage the natural disaster but it goes in vain. Presently we are investing most of our resources to mitigate the disaster, less emphasis is being given to the Resilience mechanism. The disaster resilience can be defined as the "Capacity to Bounce Back". Resilience in social systems has the added capacity of humans to plan and anticipate the future. Humans are also part of the natural world and depend on the ecosystems in which they live to survive. They continuously impact these ecosystems and contribute to their structure and functions.

Orissa is located in the eastern coast of India at 17° 49′N to 22° 34′N Latitude & 81° 29′E to 87° 29'E Longitude. Surrounded by Andhra Pradesh on the South-East, Chattishgarh on the west, Jharkhand in north, west Bengal in North-east and placeBay of Bengal in the east, it occupies a total area of 155,707 square kilometers. The state is bound on the east by the 460 kilometer coastline of placeBay of Bengal of which the Chilika lake is a part. Climate of Orissa is usually humid or hot and moist. The state is divided into five morphological units. These five units are Mountainous and Highlands Region, Coastal Plains, Western Rolling Uplands, Central Plateaus and Flood Plains.

Known as the hub of disasters, the state was recurrently victimized by climate chaos (floods, droughts, flash flood, cyclone, heat wave & lightning) causing people more vulnerable and pushing state development backward. Magnitude of fear, deprivation, poverty, hunger, trafficking, distress migration and distress sale followed by social exclusion has widened the development gap many fold, despite rich resource base.

The research objective of this study is to use the concepts of Community Disaster Resilience and vulnerability to empirically define a set of indicators that can measure elements of Community Disaster Resilience. This set of indicators can be applied across scales and contains elements of adaptive capacity, Social Capital, Economic Capital, Human Capital, Physical Capital, Natural Capital and measures of self governance.

2 Data sources and methodology

The data used for the purpose of this study were collected from various secondary sources. The main sources are from Rural School (2008) (OPEPA), Health Center (2008) (Director of Health Services), Par capital Income (2009–10) (Directorate of Economics and Statistics), BPL (1997) (Department of Panchayat Raj), Educational attainment of the population (measured by the number of years of formal schooling of the average person) (2001)(Census), Access to Safe Drinking Water and People having concrete House (2007–08) (DLHS-3), Road (2008) information's from Chief Engineer NH, Road and Rural Works, Panchayat raj and Principal Chief Conservator of forest Orissa.

To derive a composite index from a set of indicators, a wide variety of multivariate statistical techniques are available. The choices of most appropriate method depend upon the type of problem, the nature of data and objective. Many studies of social vulnerability are found in risk management literature by Peacock and Ragsdale 1997; Anderson and Woodrow 1998; Alwang, Siegel *et al.*, 2001; Conway and Norton 2002, vulnerability as a framework for measuring resilience by Cutter *et al.*(2003). However, social vulnerability is a preexisting condition that affects a society's ability to prepare for and recover from a disruptive event.

The theme of multivariate analysis is simplification and to summarize a large body of data by means of relatively few parameters (Chatfield & Collins, 1980). Many studies of social vulnerability are found in risk management literature Peacock and Ragsdale 1997; Anderson and Woodrow 1998; Alwang, Siegel *et al.*, 2001; Conway and Norton 2002, vulnerability as a framework for measuring resilience by Cutter *et al.*, (2003). The calculations for identifying Community Resilience Index of districts of Orissa are multiplication of the standardized neighborhood total values for each of the variable and the dependant variable's weight, which was found previously with the Principal Component Analysis Method. The last step of the calculation involves the summation of all weighted variable' values for each of the neighborhood and ranked according to hierarchy of their variables.

3 Discussion

The disaster history of state during last 100 years shows that state experienced 56 times flood, 40 Drought, 11 Cyclone and innumerous heat Wave, Lightning & Hail Storms. Most part of the state is vulnerable to natural disaster. Every year people experience at least a single disaster. During some of the year more than one disaster also experience by the people. The state is one of the most disaster prone state in the country in terms of loss of live and property followed by vulnerability and low resilience. The calculations for identifying Community Resilience Index levels of districts of Orissa are multiplication of the standardized neighborhood total values for each of the variable and the dependant variable's weight (Table 1), which was found previously with the Principal Component Analysis Method. The last step of the calculation involves the summation of all weighted variable's values for each of the neighbourhood and ranked according to hierarchy of their variables. The composite index for the different districts is obtained by post multiplying the Eigen vector with data matrix. The districts are grouped in to five categories on the basis of quartile methods.

The Table 2 shows the Index for the different districts and Table 3 shows the districts coming under

Table 1. Weightage given to the various indicator using first principal component.

Sl No	Indicator	Weight
1	Rural school (primary no)	0.317
2	Health center (Total medical institution)	0.490
3	Par capital NDDP(2004-05)	0.270
4	APL	0.665
5	Educational attainment of the population	0.824
6	People having concrete house	0.909
7	Road density	0.631
8	Forest cover	0.596
9	Access to safe drinking water	0.547

Table 2. Resilience Index developed for different district of Orissa.

Sl No	Ranking	Districts and score
1	Highly resilience	Sundargarh, Sambalpur, Jagatsinghpur, Cuttack, Khurda, Ganjam
2	High resilience	Gajapati, Dhenkanal, Jharsuguda, Puri, Jajpur, Anugul
3	Moderately resilience	Balasore, Mayurbhanj, Bargarh, Keonjhar, Nayagarh, Kendrapada
4	Low resilience	Kalahandi, Bhadrak, Koraput, Rayagada, Kandhamal, Bolangir
5	Least resilience	Malkangiri, Nuapada, Boudh, Sonepur, Nabarangapur, Deogarh

Table 3. Categorization of district according to the Resilience.

Sl No	Name of the district	Score	Sl No	Name of the district	Score	Sl No	Name of the district	Score
1	Anugul	0.694	11	Ganjam	1.008	21	Malkangiri	0.339
2	Balasore	0.541	12	Jagatsinghpur	0.756	22	Mayurbhanj	0.544
3	Bargarh	0.547	13	Jajpur	0.675	23	Nabarangapur	0.427
4	Bhadrak	0.468	14	Jharsuguda	0.639	24	Nayagarh	0.577
5	Bolangir	0.510	15	Kalahandi	0.448	25	Nuapada	0.386
6	Boudh	0.404	16	Kandhamal	0.504	26	Puri	0.666
7	Cuttack	0.806	17	Kendrapada	0.586	27	Rayagada	0.498
8	Deogarh	0.438	18	Keonjhar	0.561	28	Sambalpur	0.731
9	Dhenkanal	0.617	19	Khurda	0.911	29	Sonepur	0.419
10	Gajapati	0.605	20	Koraput	0.470	30	Sundargarh	0.721

different categories. The Districts those are coming under the **Most Highly Resilience** are Sundargarh, Sambalpur, Jagatsinghpur, Cuttack, Khurda, Ganjam. These districts are advance in term of cultural, educational, infrastructure and industrial development apart from economical front. Gajapati, Dhenkanal, Jharsuguda, Puri, Jajpur, Anugul comes under the **High Resilience Categories**. Except Gajapati other districts have good communication network, education and economic development where as Gajapati district bears the high resilience categories in environmental capital. Balasore, Mayurbhanj, Bargarh, Keonjhar, Nayagarh, Kendrapada are coming under **Moderately Resilience Districts** and are good in environment and average in most of other indicator particularly economic capital and social capital. The Districts those are coming under the **Low Resilience** are Kalahandi, Bhadrak, Koraput, Rayagada, Kandhamal, Bolangir. Similarly Malkangiri, Nuapada, Boudh, Sonepur, Nabarangapur, Deogarh districts of southern and western Orissa are coming under Least Resilience Districts. These districts are poor in the HDI. The District Bhadrak is only costal district coming under these categories due to its low development in economic, institutional and environmental capital. Figure 1 shows the ranking of districts of Orissa in terms of resilience.

4 Conclusion

The main purpose of this paper has been to develop a vigorous tool for use in Resilience assessment. Such a tool allows for comparative analysis and enables more in-depth exploration of the qualitative conditions that contribute to the quantitative results. Exercising any developing tool and critically examining the results are necessary to improve such a tool. This study of state of Orissa and its districts demonstrates the value of the Resilience indexing methodology given that it provides insight into resilience at state/district levels, enabling analysts to ask the next level of questions and explore directions for specific policy options that may mitigate disaster impacts.

Because we have a tough framework and methodology to evaluate recent vulnerability and resilience, we have a basis on which to begin developing realistic scenarios and analyses for projections of future resilience

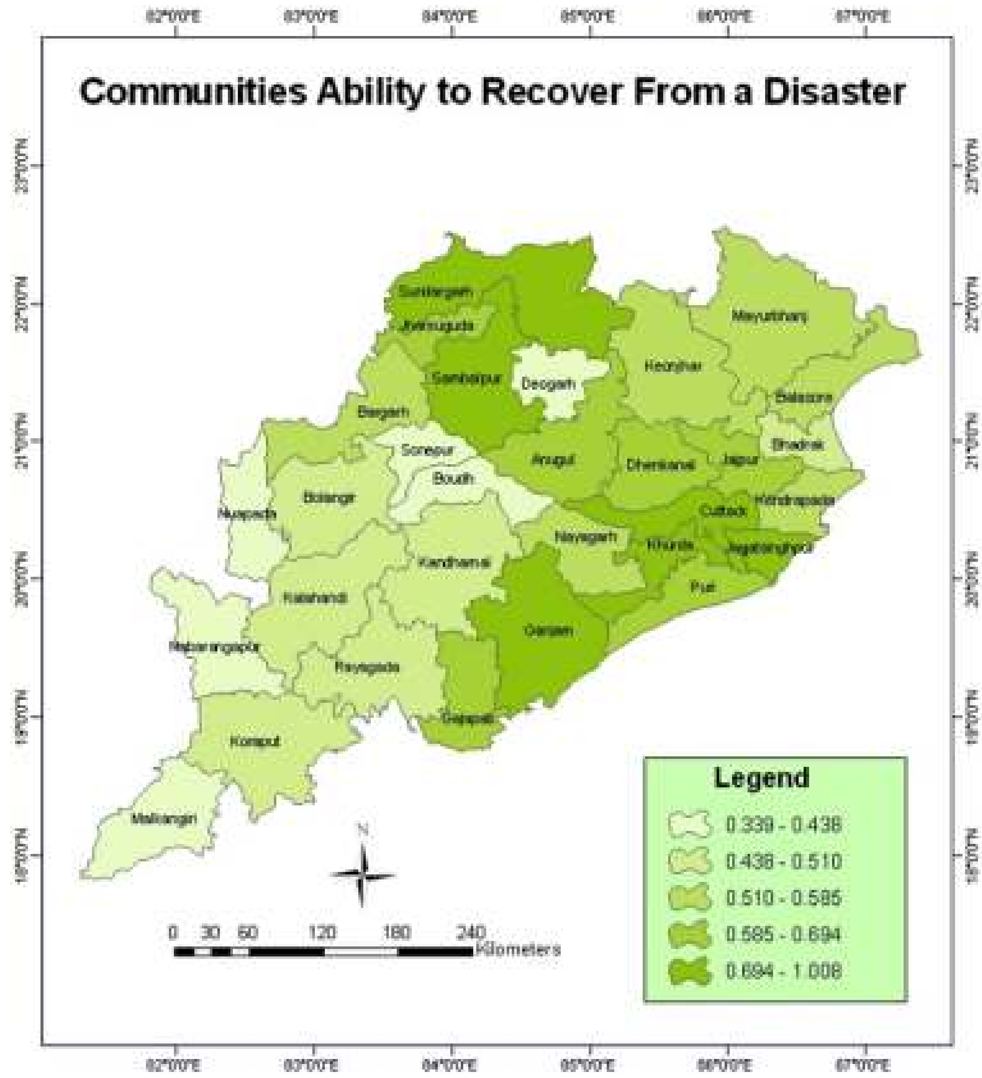

Figure 1. Showing the ranking of districts of Orissa in terms of resilience.

to disaster. Such scenarios must assimilate information about current Social Capital, Economic Capital, Human Capital, Physical Capital and Natural Capital, this integrated and differentiated information into the future. It may be precisely in this area that the most progress could be made in combining the more quantitative and more qualitative approaches to resilience.

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Disaster risk reduction and climate change

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ABSTRACT

Anomalous precipitation, extreme weather evens and dry weather are being caused by anthropogenic climate change, as reported. IPCC has included so in its most recent report. Heat waves in Europe, increasing intensity and frequency of hurricanes, in the Atlantic, Pacific and Indian ocean regions, droughts in Africa, and southern parts and flooding as weather-related disasters, due to climate change impacts. These are affecting human population and livelihoods destroying property, lives and crops in many parts of the world particularly in vulnerable areas. Natural hazards from climate related changes are increasingly affecting developing parts of the world causing an adverse import on the process of development. The World Conference on Disaster Reduction calls for international cooperation to tackle this issue, since both developed and developing countries are a rick from hazards turning into disasters. The profiles of natural hazards and disaster are changing due to changes in climate, altering the underlying environmental health and demographic risks while introducing new threats. There is a need and opportunity to reduce current and future vulnerabilities by building an and expanding disaster risk management efforts, in addition to and as part of climate change mitigation and adaptation protocols and plans.

1 Introduction

IPCC as the international authority on the science of climate change has reported that climate change forced by anthropogenic factors is happening and needs to be seriously addressed immediately. An increase in the global average temperature by an average of 0.6 °C over the last century has been observed which has been linked to increasing emissions of greenhouse gases, particularly carbon dioxide, due to human activities and developmental efforts.

Melting of glaciers in Himalayas and Alps and Arctic regions, is increasing mean sea level around the world, together with rise in ocean temperatures on an average, and causing sea water to expand. Changes in the behavior and distribution of flora & fauna and biodiversity losses are being detected and reported by IPCC (2001). The ten warmest years have all occurred in the decades since 1990, and particularly notable since the mid-90s, (WMO 2004). Global average temperatures are projected to increase by 1.4 to 5.8 °C by the end of the century, as compared to 1990 levels. This is unprecedented in the history of last millennium (IPCC 2001) and will reflect as climate change impacts due to temperature increases on a local and regional scale affecting large parts of the world, with major implications for disaster risk management, in the context of increasing exposure to hydro-metallurgical hazards, besides influencing the vulnerability to environmental hazards, and thus having implications for disaster management and climate change adaptation.

2 Vulnerability profile challenges

Increasing temperatures will most likely cause heat waves and dry weather in most parts of the world, even land areas, (IPCC 2001) having disasters impacts even in developed countries of USA, America & Asia. Heat wave with temperatures rising above 40 °C has been reported in Europe (WMO 2004) which accounted for more than 30,000–50,000 deaths (Koppe *et al.*2004). Human induced green house emissions have apparently doubled the risk for a recurrence of such heat wave conditions. Anomalous precipitation is also more likely to occur from higher mean sea temperatures leading to higher probabilities for floods, avalanches, storms and sea erosion and heightened risk to life, crops and property as a result (IPCC 2001). Mid-latitude continental interiors may also experience extreme dry weather conditions increasing the risk of droughts. Intensity & frequency of cyclones, hurricanes and typhoons has been intensifying not only in Atlantic regions, but also in the pacific and tropical regions (IPCC 2001). El Nino events are becoming have frequent, as compared to La Nina episodes. The heat wave conditions and droughts and floods associated with EL Nino events are likely to be intensified by climate change. The recent floods in Australia and anomalous precipitation, due to a more intense La Nina event, points towards this. The incidence of natural catastrophes per decade has increased four fold with 14 times economic losses for the decade since 1950–1959 (Munich Re, 2000). Uncontrolled urbanization in hazard prone areas, demographic pressures and environmental degradation have all contributed to this. There is also improving information which influences the reported trends. Weather related hydro-metallurgical hazards has been on an increasing trend. The existing mechanisms are insufficient in many countries to cope with the vulnerability profiles.

Climate sensitive livelihoods like farming and animal husbandry, and rural livelihoods are more impacted by extreme weather events and climate change related weather concerns. People in mountainous terrains and coastal zones are also at particular risk on account of climate change related weather variabilities and change in average climatic conditions, in addition to the risks posed by disasters due to climate change related extreme weather events. These are in addition to other hazards like geological ones or war related and other such events. Food security and livelihoods in poor regions of the world, like in Sub-Saharan Africa are prone to heightened vulnerabilities (Fischer *et al.*, 2001). Impacts of climate change are not more exacerbations of existing threats and disasters; global warming may induce impacts which are new to a region and hence presenting logistic and infrastructure problems in disaster management. Island nations are particularly so impacted by perishing coral reefs, which is caused by increasing absorption of carbon dioxide by oceans, and mean sea temperatures. Coral reefs sustain fisheries and provide protection against stern surges. The island nations are hence not only threatened by projected vulnerabilities due to mean sea level rise and increasing intensity of storms and erosion events, but also by such threshold events arising from climate change, presenting new challenges.

3 DRR threshold events

Glofs are an example of threshold events, in the context of climate change and DRR, an understanding of which is important in eco-system health and management and for disaster risk reduction from compounded impacts. Glofs are glacial lake out burst floods with destructive down-stream effects arising from accumulation of water in dams from glacial melts in an unprecedented and unexpected manner. Valleys are increasingly at risk due to such floods, and global warming is increasingly causing melting of glaciers in many mountainous remains. Earlier settlement policies may not have reckoned with such emerging threat patterns arising from climate change impacts.

Climate sensitive diseases are spreading into regions where increase in temperatures and humidity due to climate change pose the problems of new and/or more virulent types of infections and infestations from vector-borne diseases and pathological variants (Mc Michael 2003). Species are disappearing from endemic areas in biodiversity spots due to change in average temperatures, and invasive species are emerging new areas, including flora fauna (IPCC 2001). Research on such thresholds are needed for strategic planning. The climate system is a complex one with multiple feedback loops between ocean atmosphere and terrestrial ecosystems. Climate models help to study and understand these systems and forecast the changes.

1990–1999 has been declared as the International Decade for Natural Disaster Reduction (IDNDR) by UN general assembly. The World Conference on National Disaster reduction in Yokohama, Japan, held in conceived the Yokohama Strategy & Plan of Action for a Safer World. Every country is bound to protect its people, infrastructure & socio-economic and ecological assets from the impact of natural disasters.

4 DRR-adaptation and mitigation

A new paradigm of a more comprehensive and proactive nature including research-based projections, vulnerability assessment, climate change mitigation & adaptation plans, risk reduction strategies, etc are needed. Any disaster has underlying social, economic and ecological vulnerabilities which need to be understood and addressed proactively rather than in a hind-sight oriented approach (UNISDR 2004).

A multi-hazard focus is required in the context of climate change impacts compounding hydro-meteorological hazards directly and the risk factors arising from geological hazards. For example, coastal regions of Equator and N. Peru are prone to EL Nino event related increased precipitation and flood events. This is in addition to the risks from proneness to earthquakes, volcanic eruptions, cold spells, avalanches and land slides besides extreme weather related incidents of droughts and floods.

Disaster manage has to provide for both in terms of a contingency based approach and long-term strategy for preventive management based on a science-based approach. The risk of a disaster and its probabilities are assessed on short, medium and long-term time slabs based on hydro-meteorological events, climate change related weather variabilities and geological scale events like earthquakes. We have to move to concrete measures that reduce existing vulnerabilities of human and natural systems, as part of adaptation to climate change, besides understanding it better and mitigation efforts. The initial framework on adaptation was particularly concerned with elucidating the climate change particular regions are prove to (Morza 2003) IPCC has also released guidelines for adaptation studies, with a focus on identify regional impacts due to climate change (Carter *et al.*, 94). The adaptation policy framework (APF) developed by UNDP outlines concrete steps, encompassing current risks and future scenario. The Climate Change Decision making is example of a regional adaptation and mitigation plan. UNFCCC has established a set of guidelines for climate change adaptations in the context of LOCs (Least Developed Countries). (UNFCCC, 2002) The World Bank has developed a screening tool to identify climate sensitive projects and vulnerabilities to climate change. Similar initiatives are being undertaken by other US agencies like USAID, WHO, UNDP etc.

5 Financing framework

A financing framework for adaptation is largely an outcome of the UNFCC process. As part of the Mamakesh accords an agreement on various funds to support adaptation measures was arrived at. These funds to support adaptation measures was arrived at. These funds include LDC fund, special Climate Change (SCC) Fund and Adaptation fund. LDC fund is expected to contribute to the enhancement of adaptive capacity to address the climate change challenge, including national strategies for sustainable development. The emphasis is on providing LDCs with equitable access to funding for implementation of National Adaptation Plans of Action (NAPAs). The Global Environmental Facility (GEF) is expected to support NAPAs, on a case based fund support approach. The SCC contributes to sustainable development efforts (WSSD) and MDGs by integrating climate change and development issues and considerations.

Adaptation fund was established under Marrakesh Accords and is linked to the Kyoto Protocol. The fund is expected to finance concrete adaptation projects in developing countries which are parties to the Kyoto Protocol. The funds are in addition to bilateral and multi lateral contributions and receive a share of carbon credits from CDM activities (above stipulated limits). Estimated to amount to only 3 Million dollars to 5 Million dollars/year over the 1st commitment period of Kyoto. GEF has allocated 50M USD in the business plan for 2005–2007 to strengthen the learning effort on how best to address adaptation issues.

6 Converging agendas

Need to address vulnerabilities to climate change through adaptation efforts, complementing mitigation efforts. Both climate change adaptation and Disaster Risk Reduction or Disaster Management address vulnerabilities. Risk evaluation, vulnerability assessment and possible remedial measures are important under both. The emphasis is on a continuous and forward looking process of risk evaluation. But time horizons tend to be different. DRR more concerned with the present. Emphasis is on vulnerabilities through past disasters and the focus is on near term trends for 5–10 years. Climate projections are for 20, 50 or for 100 years. Climate change mitigation is addressed to limit onset. The scope of DRR goes beyond climate related disasters since preventive measures has to address hydro-meteorological and geomorphological hazards.

A typical case with livelihood implications is one of Mekong Delta : Vietnam. Recent Developments rendered this zone more vulnerable to floods. During pre-70s there was single cropping, in consonance with rainfall and seasonal floods in rainy season. Floating rice war grown. This could tolerate various flood levels. Yield was low, but a minimum production was guaranteed to preserve livelihood system. HYVs introduced in the 80s, short growing periods, change in cropping patterns. Double cropping of rice widely disseminated in Mekong Delta. Cropping system adjusted to seasonal flooding. Short duration varieties in non-flood season. Since 90s there is a diversified cropping system. Systems exposed to annual floods. Incidence intensity has increased. The cropping patterns and livelihood systems not adapted to annual floods in Mekong Delta. Another one relates to the Carribean. Planning for adaptation to climate change, funded by GEF in the late 90s coordinated effort by WORLD BANK, OAS, Univ of WEST INDIES plus 12 countries of Carribean Community (CARRICOM). Planning was for adaptation to impacts of sea level rise on coastal and marine resources. There was a Strong coastal focus, and Adaptation strategies related to mitigating the impact of coastal storms and hurricanes-Caribbean Disaster and Emergency Response Agency + MACC (Mainstreaming Adaptation to Climate Change) team worked together for adapting to climate change and mitigating hydro meteorological hazards. Carribean Development Bank facilitated guidelines for natural hazard impact assessment and integration into EIA (Environment Impact Assessment).

There is need to develop hence an integrative framework for Risk Management in the context of climate change and natural disasters. Remedial measures aimed at reducing vulnerabilities should be part of the development process (Simms *et al.*, 2004). Poor people and less developed regions are more vulnerable to climate change related risks and other natural disasters. Comprehensive risk management efforts and frameworks are lacking, and mostly the measures and approaches are adhoc in nature. Concerns of sustainable development and MDGs are better served if there is better integration of DRR and Climate adaptation/mitigation protocols and efforts. Development planning provided the larger canvas for the converging agenda. It needs to recognize a wide array for consideration like parameters related to environment and education, healthcare and infrastructure. Priorites need to be established and DRR and climate adaptation should integrate with the development process. Information from development agencies and governmental and non-governmental agencies need to be integrated and utilized to compile data sets of micro and macro economic information relevant to the process of development planning in the context of the converging agenda. The DRR plans of states and nations need to be refined in this light.

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Prediction of end of break/active phases of summer monsoon over India

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ABSTRACT

India receives approximately 80% of annual rainfall during southwest monsoon and it is the key factor which affects the economy of the country. To know the interruption of monsoon by prolonged spells of sparse rainfall (break monsoon) during the mid-monsoon months of July and August over India is of vital importance. With this aim, present work has been carried out. The study brings out that after initiation of break (active) phase over India, total rainfall amount and its areal coverage over China increases (decreases). Time when it start decreasing (increasing), after attaining highest (lowest) values; marks the beginning of end of break (active) phase. The study certainly gives some clue about the end of break/active phase, although it does not give any signal of initiation of break/active phase. Departure in days of end of break/active phases from study and as reported, is in the range −2 to +2 (except 3 cases out of fifteen) for breaks and 0 to −3 for active phases (except one case). Study points out that the highest total rainfall over China remains more than 90 cm for break phases and the lowest total rainfall remains less than 70 cm in active phases.

1 Introduction

Southwest Monsoon shows large intra-seasonal variations; there are spells of heavy rainfall and weak/break monsoon conditions. Several scientists such as Krishnamurty *et al.*(2000), Goswami *et al.*(2001), Annamalai *et al.*(2001) etc have studied intraseasonal/interanuual variability of summer monsoon. The duration of active and break days during the peak monsoon months of July and August decides the fate of the monsoon rainfall over Indian subcontinent. The timing and the duration of the active and break events are particularly important for an agricultural country like India, where 60-80 percent of the mean annual rainfall is received during the southwest monsoon season. Further, prolonged breaks can adversely affect the crop development, growth and yield.

2 Data

We refer an event as a break or active phase following U. S. De *et al.*(1998) and with those identified by the conventional methods of India Meteorological Department. Data which is rain-gauge based 0.5 degree daily grid precipitation products developed by the Asian Precipitation Highly Resolved Observational Data Integration Towards Evaluation of water resources (APHRODITE's water resources project http://www.chikyu.ac.jp/precip/) has been used for this study.

3 Results and discussions

The Indian summer monsoon, which last for four months (June to September), is characterized by periods active and weak in monsoon conditions. It is the duration of these active (periods of high rainfall over the Indian subcontinent) and weak/break (periods of deficient or no rainfall over the Indian subcontinent) monsoon phases which decides the fate of the agriculture production of the Indian subcontinent. In addition to the above phases, a special feature known as 'break in monsoon conditions' occurs (Ramamurthy, 1969). According to

Table 1a. Maximum rainfall (cm) and date of end of break phase as reported and from study for break phases.

Sr. No.	Break phase duration	Max. rainfall Amount(cm)/Date	Break phase ended on As reported	Break phase ended on From study
1	17 July–3 Aug. 72	200/20 July, 120/28 July	3 Aug.	1 Aug.
2	1–6 Sep. 72	150/2 Sep.	6 Sep.	7 Sep.
3	23 July–1 Aug. 73	130/25, 29, 31 July	1 Aug.	3 Aug.
4	24–28 July 75	160/30 July	28 July	2 Aug.
5	16–21 July 78	90/20 July	21 July	22 July
6	17–23 July 79	140/19 July	23 July	23 July
7	15 Aug.–3 Sep. 79	140/22 Aug., 1 Sep.	3 Sep.	3 Sep.
8	26–30 July 81	120/26 July	30 July	1 Aug.
9	23–27 Aug. 81	130/24 Aug.	27 Aug.	27 Aug.
10	20–24 July 84	110/25 July	24 July	29 July
11	27–31 July 90	120/31 July	31 July	5 Aug.
12	1–5 July 96	150/3 July	5 July	7 July
13	23–28 July 2002	190/23 July	28 July	27 July
14	15–21 July 2004	180/18 July	21 July	22 July
15	16 Aug.–9 Sep 2004	120/27 Aug. 90/5 Sep.	9 Sep.	11 Sep.

Table 1b. Minimum rainfall (cm) and date of end of active phase as reported and from study for active phases.

Sr. No.	Active phase duration	Min. rainfall Amount(cm)/Date	Active phase ended on As reported	Break phase ended on From study
1	7–20 July 72	23/17 July	20 July	20 July
2	4–19 Aug. 72	20/11 Aug.	19 Aug.	18 Aug.
3	1–23 Aug. 73	45/5 Aug.	23 Aug.	21 Aug.
4	11–28 Aug. 75	25/21 Aug.	28 Aug.	25 Aug.
5	1–15 July 78	20/6 July	15 July	13 July
6	1–16 Aug. 79	20/6 Aug.	16 Aug.	13 Aug.
7	2–19 Aug. 81	40/7 Aug.	19 Aug.	16 Aug.
8	10–19 July 84	40/16 July	19 July	19 July
9	18–26 July 90	60/22 July	26 July	26 July
10	10–18 July 96	70/12 July	18 July	16 July
11	19 Aug.–12 Sep. 2002	15/31 Aug.	12 Sep.	14 Sep.
12	12–23 Aug. 2004	30/17 Aug.	23 Aug.	20 Aug.

the traditional break in monsoon conditions, the following synoptic conditions occur over the Indian subcontinent:

(1) The migration of monsoon trough to the foot hills of Himalayas

(2) Absence of low level easterly wind over the north India

(3) Increased rainfall activity over the foot hills of Himalayas and decrease of rainfall over the rest of the country.

In the present study, we refer an event as a break or active phase following De *et al.*(1998) and with those identified by the conventional methods of India Meteorological Department. Accordingly, fifteen break phases and eleven active phases of Indian summer monsoon during the period 1974–2004 have been examined (Tables 1a–b). For all these periods, China total rainfall was plotted. It is found that during initiation of break phase in Indian summer monsoon, rainfall amount and its areal coverage increase over China. The onset of its decrease marks the beginning of end of the break phase. Exactly opposite trend is observed during active monsoon phases. As the study is related to the active and break phases of India monsoon, a representative rainfall distribution over Indian region during active phase 18–26 July 1990 (23–25 July 1990 as a sample) and break phases 27–31 July 1990 (26–28 July 1990 as a sample) along with China region are presented in Figures 1 and 2 respectively. It is seen from the Figure 1 that during active phase as the rainy area over central parts India increases, rainy area over China decreases. In Figure 2 it is clearly seen that as the rainfall from central parts of India reduces and started confining at foot hills of Himalaya, rainy area over China increases.

The duration of break phase, maximum rainfall values reached along with date, date of end of active phases as reported and from this study are shown in Table 1a. Figure 3 (upper left panel) shows peak rainfall values reached during break phases and it is found more than 90 cm. Out of fifteen break phases, it is observed that in twelve break cases departure in days of end of break phase by this study from end of break as reported are in the range −2 to +2 days and is shown in

Rainfall (mm) : 23−25 July 1990

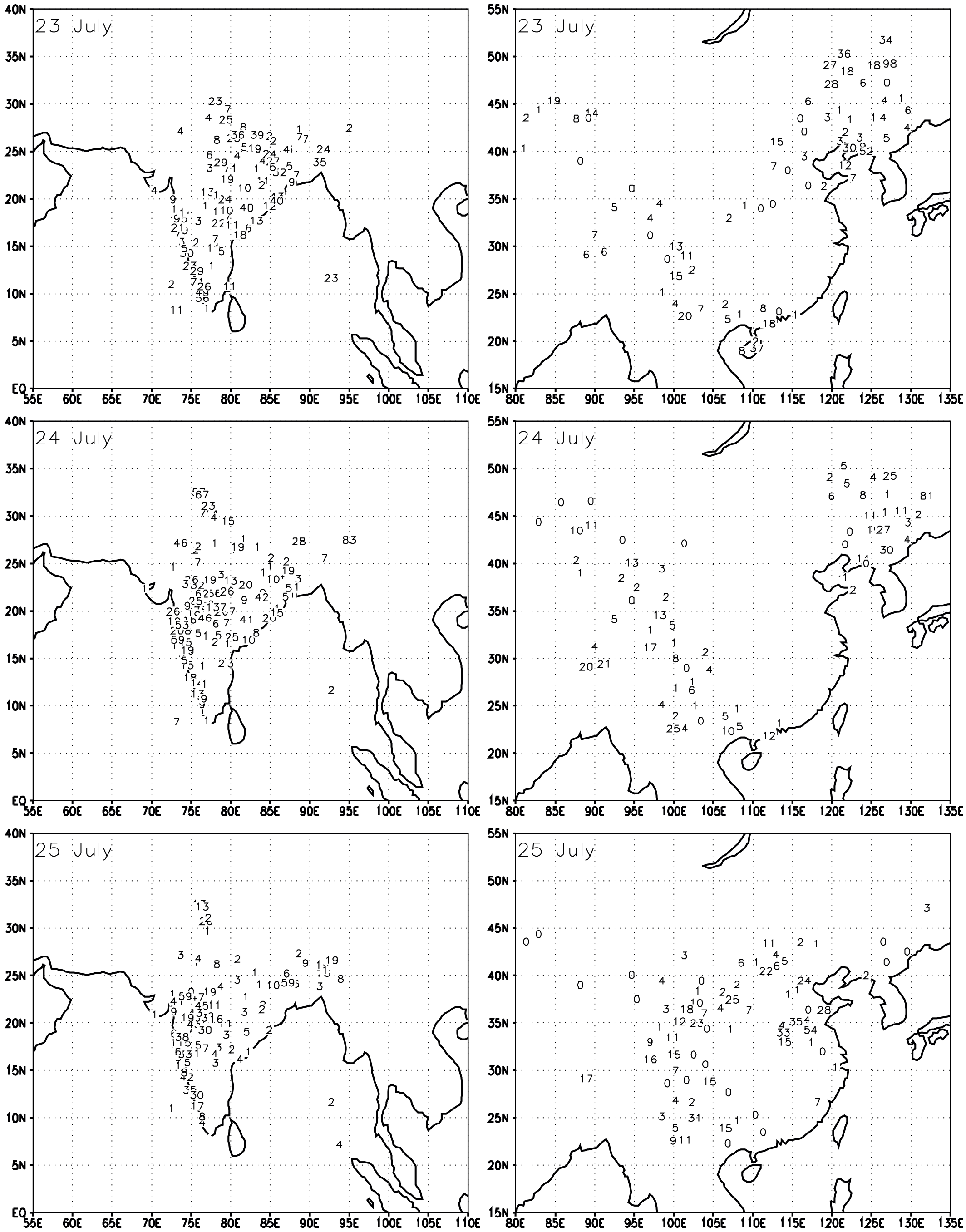

Figure 1. 23–25 July 1990 rainfall: India and China.

Figure 3 (lower left panel). Range −2(+2) days means end of break by study is two days earlier (later) than reported. For remaining three breaks, end of break phase from study is delayed by 5 days. The duration of active phase, minimum rainfall values reached along with date, date of end of active phases as reported and from this study are shown in Table 1b. Figure 3 (right upper panel) shows lowest rainfall values reached during active periods and it is found to be less than 70 cm. For eleven out of twelve active phases, it is observed that the departure in days of end of active phase from study and as reported is in the range 0 to −3 days and is shown in Figure 3 (right lower panel).

4 Conclusions

This study clearly shows that there exists definite link between break/active phases over Indian monsoon and rainfall over China. The study brings out that after initiation of break (active) phase, total rainfall amount and its areal coverage over China increases (decreases). Time when it starts decreasing (increasing), after attaining highest (lowest) values; marks the beginning of end of break (active) phase. The study certainly gives some clue about the end of break/active phase, although it does not give any signal of initiation of break/active phase. Departure in days of end of break/active phases from study and as reported is in the range −2 to +2

Rainfall (mm) : 26–28 July 1990

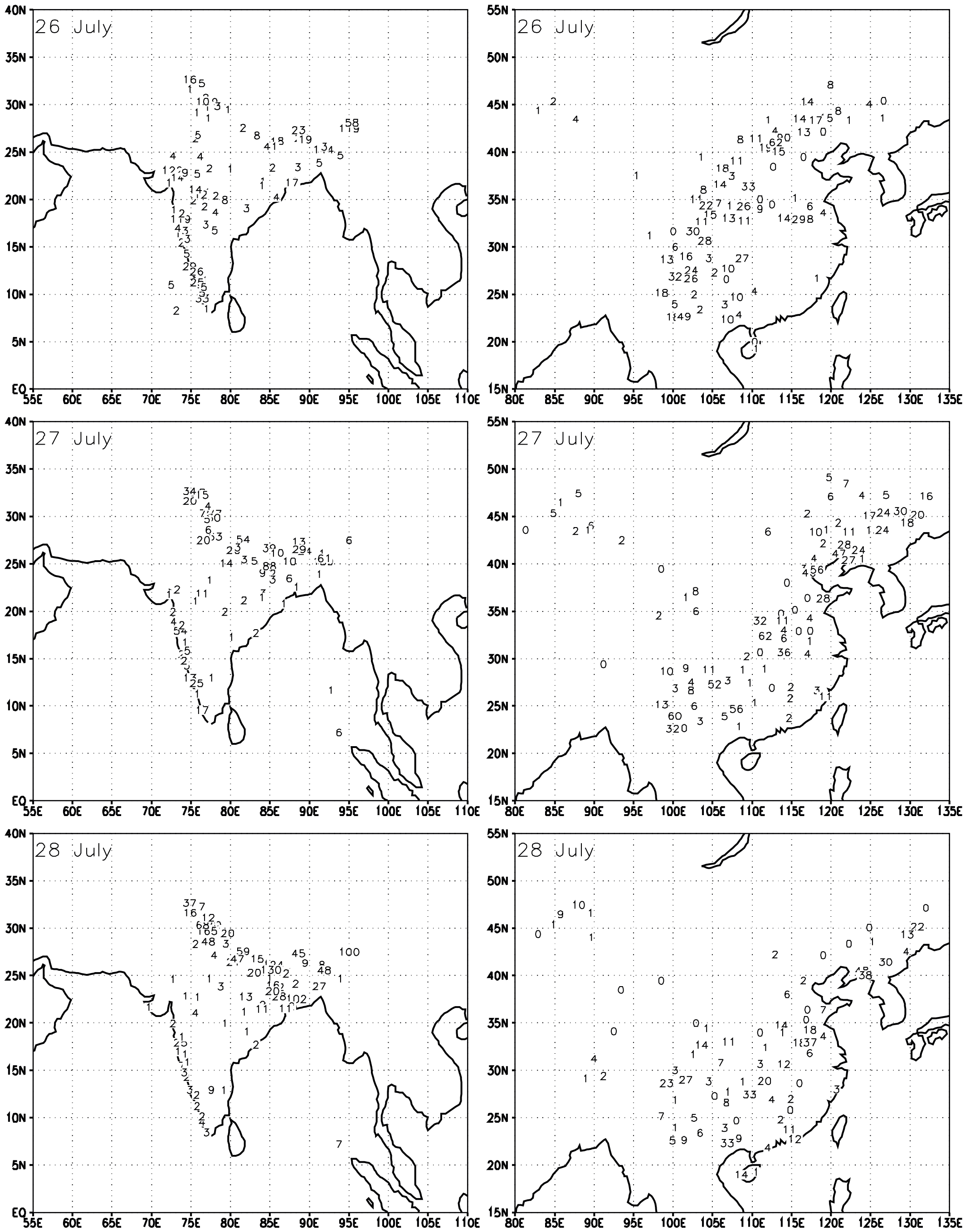

Figure 2. 26–28 July 1990 rainfall: India and China.

(except 3 cases out of fifteen) for breaks and 0 to −3 for active phases (except one case). Study points out that the highest rainfall over China remains more than 90 cm for break phases and the lowest rainfall remains less than 70 cm in active phases.

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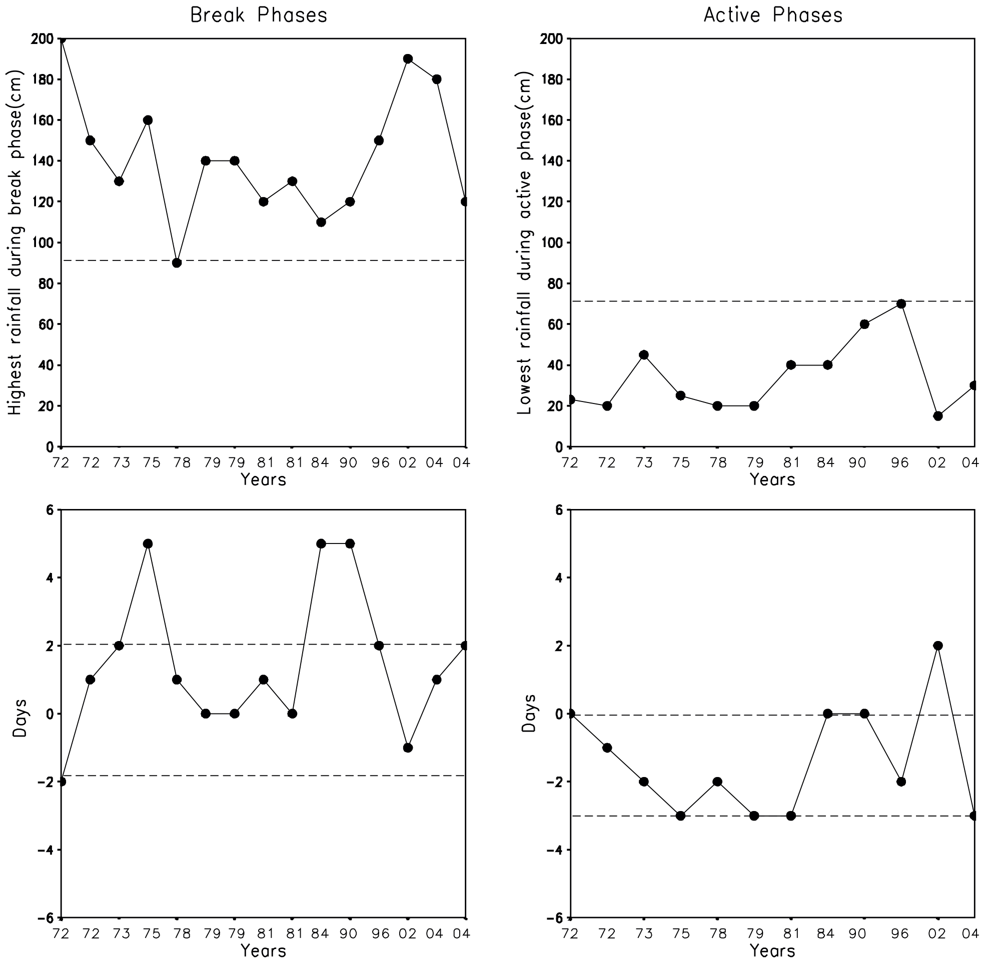

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Use of free and open source geospatial tools and technology in disaster management

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Abstract

Local Spatial Knowledge (LSK) is one of the major prerequisites in effective disaster management. GIS is an important tool for understanding and communicating the spatial distribution of risks associated with an area. Free and Open Source GIS (FOSS GIS) tools and technologies are of great help to aid organizations, NGOs and local authorities for cost effective disaster management activities. This paper is an attempt to highlight the potential of FOSS GIS tools and technologies in disaster management. Also, the practical use of Google Earth as a free online remote sensing data set is highlighted for cost effective survey and mapping purpose.

1 Introduction

The term 'disaster', meaning 'bad star' in Latin, is defined as an impact of a natural or man-made hazard that results in economic disruption, loss of life, property and causes human suffering or creates human needs that the victims cannot alleviate without assistance. The word's root is from astrology and implies that when the stars are in a bad position, a bad event is about to happen. In a recent document published by the United Nations Development Programme (UNDP) in the Americas, a disaster is defined as 'a social crisis situation occurring when a physical phenomenon of natural, socio-natural or anthropogenic origin negatively impacts vulnerable populations causing intense, serious and widespread disruption of the normal functioning of the affected social unit' (Wattegama, 2007).

Natural disasters have their greatest impact at local level, especially on the lives of poor people. The rich are literally unaffected by the disaster. The Local authorities and the NGOs are the only hope for the poor in facing any disasters so it is their responsibility to live up to the expectation of the poor people. Disaster management can be defined as the discipline and profession of applying science, technology, planning and management to deal with extreme events, that can injure or kill large numbers of people, cause extensive damage to property, and widespread distribution to society. In a developing country like India Disaster Management is limited to Post-disaster Recovery, Rehabilitation and Reconstruction. In the developed countries huge funds are spent towards Disaster planning and preparedness measures which considerably reduce the overburden on post disaster activities, and also saves valuable lives. Of course neither human intervention nor technology is capable of stopping any disaster but their impact on the society can be reduced by preparing communities to be more disaster resilient. During a catastrophe, generally, the people who are vulnerable are clue less of the magnitude of the hazard or how to tackle the crisis situation. This unawareness is a potential threat to their very existence. This situation arises due to lack of proper planning and disaster preparedness measures implemented at the community level.

2 Crisis informatics or disaster informatics

This is the study of the use of information and technology in the preparation, mitigation, response and recovery phases of disasters and other emergencies. It is an emerging field showcasing the application of information communication technology (ICT) in Disaster Management. Crisis informatics concerns with the extended social arena of disaster response which includes preparation, warning, response and recovery. Utilizing modern techniques of geo-informatics such as, Remote Sensing, GIS and GPS actions can be solicited in more systematic and precise way to respond to disasters, mitigate their effect and to make a better preparedness plans. Information plays a crucial role in Disaster Management. The success of disaster management depends on the availability of information, dissemination of that information and the effective use of that information. GIS is one such technology where spatial data can be effectively utilized for Disaster Management.

GIS is a valid tool in Disaster Management activities like Preparedness, Mitigation, Recovery, and Disaster Response. GIS can be defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. Spatial features are stored in a coordinate system that references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. Most of the data requirements for disaster management are of a spatial nature and can be located on a map. GIS can be used effectively to achieve this objective. Distributed information and lack of a single disaster data repository is one of the major problems in disaster management. GIS helps to organize spatial data during disasters. GIS-based space technology solutions have become an integral part of disaster management activities in many developed and some developing countries. Using a GIS, it is possible to pinpoint hazard trends and start to evaluate the consequences of potential emergencies or disasters. When hazards are viewed with other map data, such as buildings, residential areas, rivers and waterways, streets, pipelines, power lines, storage facilities, forests, etc., disaster management officials can formulate mitigation, preparedness, response and possible recovery needs. More importantly, human life and other values (property, habitat, wildlife, etc.) at risk from emergencies can be quickly identified and targeted for protective action (Johnson, 2000). After potential emergency situations are identified, mitigation needs can be addressed. This process involves analyzing the developments in the immediate aftermath of a disaster, evaluating the damage and determining what facilities are required to be reinforced for construction or relocation purposes. During the preparedness and response phases, GIS can accurately support better response planning in areas such as determining evacuation routes or locating vulnerable infrastructure and vital lifelines, etc. It also supports logistical planning to be able to provide relief supplies by displaying previously available information on roads, bridges, airports, railway and port conditions and limitations. Apart from this, activities such as evacuee camp planning can also be done using GIS. It can also provide answers to some of the questions important to disaster management, such as the exact location of the fire stations if a five-minute response time is expected or the number and locations of paramedic units required in a specific emergency. Based on the information provided by GIS, it is also possible to estimate what quantity of food supplies, bed space, clothes and medicine will be required at each shelter based on the number of expected evacuees. By utilizing a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralize and visually display critical information during an emergency. This would facilitate scientists and disaster managers in creating models that would simulate trends observed in the past, present and also assist with projections for the future (Wattegama, 2007). This paper is an attempt to highlight the potential of FOSS GIS tools and technologies in disaster management. Also, the potential of Google Earth as a tool for free online remote sensing data set is emphasized. This briefing paper is aimed at relief agencies and NGOs who are considering the use of Google Earth and open source GIS tools in their work. It is written, as far as possible, at a non-technical level but assumes a working knowledge of Google Earth and Quantum GIS.

3 Materials and methods

In disaster management work the real power of maps is as a means of communicating and sharing complex information that is a crucial resource in disaster response. Till now, the only way to assemble spatial data and produce real-time maps was by using Proprietary GIS software and Geo-referenced Satellite images purchased for huge amount of money. But Google Earth has changed this story, Google Earth (Figure 1) and its open data standard KML now provide a way for disaster aid workers to view a variety of spatial data, collected and use the spatial for their activities. Practical applications of these methods in the field are discussed in this paper. This briefing paper is aimed at relief agencies and NGOs who are considering the use of Google Earth in their work. It is written, as far as possible, at a non-technical level but assumes a working knowledge of Google Earth and Quantum GIS. Google Earth can properly be described as a GIS, however GIS describes conventional software such as ESRI's ArcGIS or MapInfo, and the growing number of open source or free software's like QGIS that offer broadly equivalent functions. The only difference is that these software's have advanced GIS analysis functions and geo-processing capabilities which Google earth lacks but these GIS software's don't have satellite imagery or map data pre-installed to work on. Since its launch in 2005, Google claims that 350 million copies of Google Earth software have been downloaded world wide. Exchanging spatially referenced data using Google Earth formats like KML and KMZ is really important. On the other hand, by comparison with GIS, Google Earth is not a sophisticated cartographic map drawing system, or a means of

Figure 1. Google earth interface.

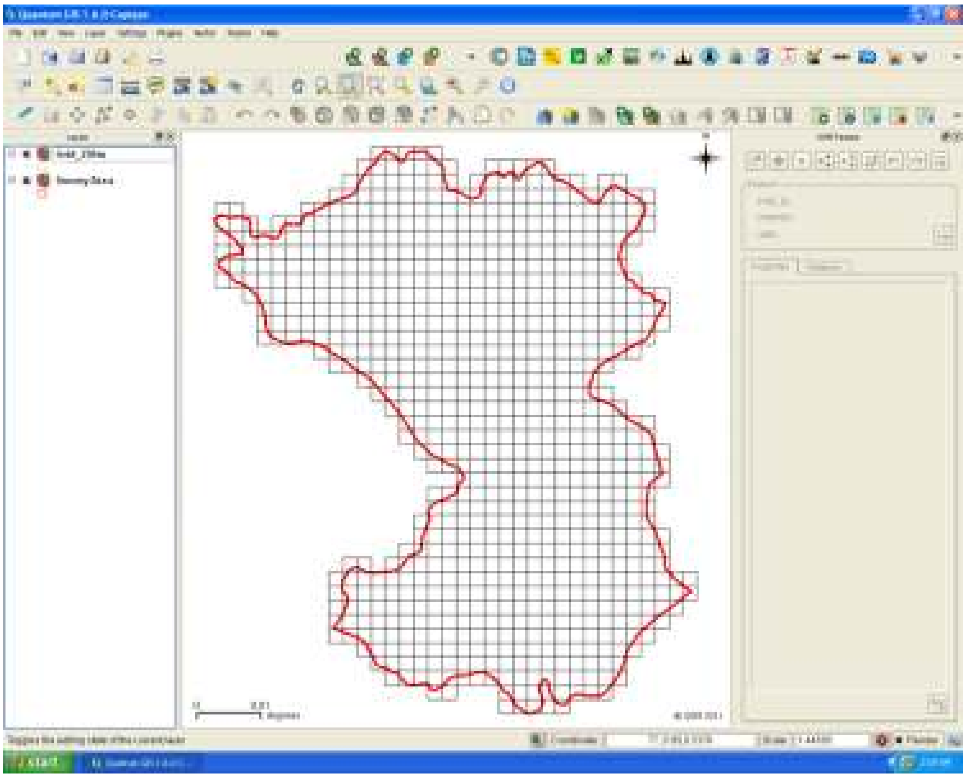

Figure 2. Quantum GIS interface.

doing complex spatial analysis but its easy to use functionality helps the growth of public interest in geospatial technologies in general. Google Earth can handle four main classes of spatial objects: points, polygons, paths and overlays. The huge advantage of using Google Earth is that non-experts can use it in an intuitive way to visualize relatively simple data, without having to worry about geo-referencing or editing complex geometry.

Disaster aid organizations need and use spatial data in a number of different ways in the field. Relief work-

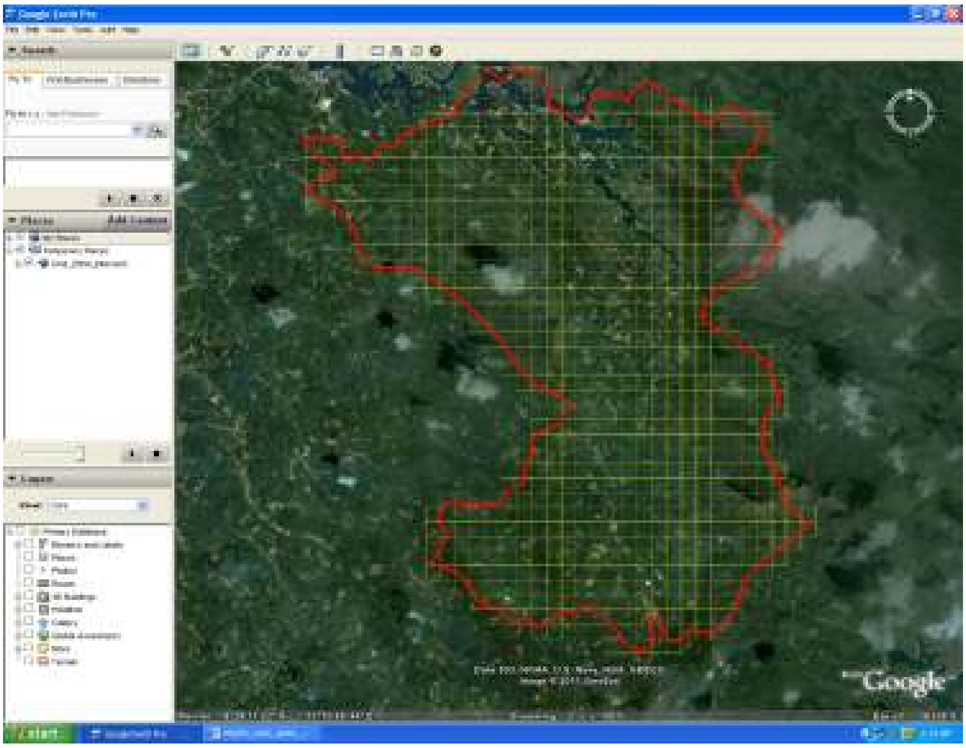

Figure 3. Study area divided into 250 sq. meter grids.

Figure 4. Google earth image with grid used for surveying houses.

ers need base maps for reference and navigation: to orientate them to the geography of the affected area, to locate relevant towns and villages, and to plan and follow routes to reach them. Relief workers need maps showing up-to-date relevant situation data gathered by others. Government agencies and NGOs also need maps showing numbers of affected people, shelter locations etc. Google Earth, can help to serve these purposes, spatial data extracted from Google earth can be converted to other geospatial formats like shape files with the help of GIS software's and necessary maps can be generated for specific purpose. This has important benefits for Aid

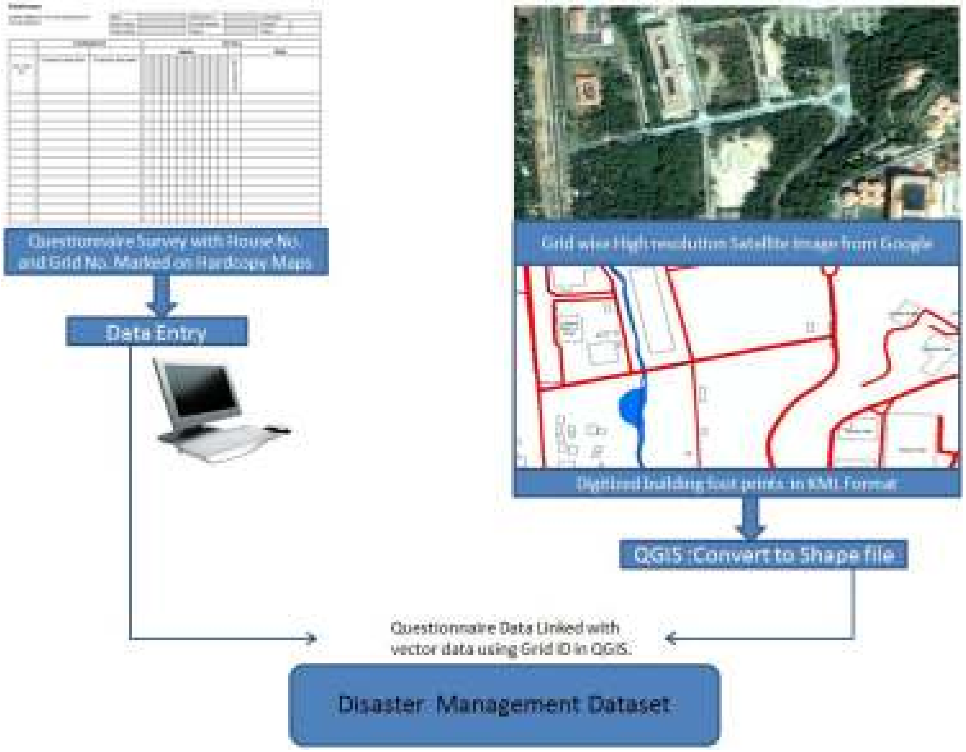

Figure 5. Using questionnaire and google earth printouts for cost effective survey.

organizations and NGO's. This delivers one of the long-promised benefits of GIS in emergencies — that is the easy visualization and identification of spatial gaps and locations for response. It can be seen then that Google Earth is potentially a valuable tool for visualizing and exchanging data in emergencies. Spatial data can easily be shared by this method and KML files can be shared among organizations instantly. Spatial data has been deficient in emergency operations and GIS professionals with such experience in using Google earth for extracting spatial data for disaster management activities are very less.

Proprietary GIS software is costly for local level community preparedness plans. FOSS GIS encompasses its open source; agile, free sharing property into GIS software thus making it more popular as a decision support tool for cost effective community level disaster preparedness and response plans. Quantum GIS (QGIS) is user-friendly desktop-GIS released under the General Public License (GPL) and is available for Linux, and Windows operating systems. QGIS (Figure 2) can freely be downloaded, installed and configured by any person having basic computer knowledge.

FOSS GIS promotes the use of geo-information technology in disaster management at the local level with minimal financial investment. Quantum GIS (QGIS) is free GIS software that supports Linux, Windows and Mac operating systems, it is freely downloadable, can easily be installed and configured. The local authorities can reap this fruitful technology with minimum infrastructure like a computer, internet and printer, provided the local authorities should be trained in using this technology. This will enable in building a relevant and up to date disaster informatics dataset at the grass root level that will enhance the effectiveness of district, state and national disaster informatics data repository. The local knowledge on disasters is highly important; it suggests a way to mobilize available human and technical resources in order to strengthen a good partnership between local communities and local officials. More efforts should be made towards capacity building of local people by use of available resources. It will help in developing their own knowledge base, and to develop methodologies like public participatory GIS, that promotes activities for reducing risks in a sustainable way thereby increases disaster resilience of the community by making people think spatially there by helping them better understand the area they live in and the risk they are exposed to.

This paper is a portion of the ongoing project in Centre for Advanced Remote Sensing and Environment Studies (www.mapcare.org). The study area shown here is Amboori Panchayat in Thiruvananthapuram district. This project is aimed at capacity building and strengthening of the local authorities in disaster preparedness. Amboori being a landslide prone area require much care in disaster preparedness and mitigation. The detailed survey of the Panchayat is carried out to map the settlements, risk prone areas and possible rescue shelters. The final work will be submitted to the Panchayat and the government in strengthening the disaster management activities in the area. This method will prove to be a cost effective way for the large scale survey of similar areas where the cost in GPS survey can be considerably reduced. The entire Panchayat is divided into grids of 250 sq. meter (Figure 3); using QGIS software. The detailed mapping of the area is done using the hardcopy maps generated from Google earth images, the building foot prints are already digitized, overlaid in the hard copy maps, with proper house number and grid number. A questionnaire survey will be done along with the plotting of the exact house location on the hardcopy maps (Figure 4). This methodology also helps in the detailed topographic and demographic analysis for the area. This data will then be manually entered as an attribute in the QGIS shape file for each building footprints.

Thus the main concern in developing a disaster preparedness and response mapping system includes the identification of each and every settlement at risk depending upon their proximity to a particular hazard in an area. The detailed and large scale survey can be carried out using hard copy maps generated from Google earth imagery, which will survey the entire area with minimum cost. The high resolution satellite images in Google Earth can be used to extract spatial location for the settlements, roads, water bodies, lowlands and terrain in an area. The Google Earth image can be downloaded by taking different screenshots and mosaicing them in any image processing software like Gimp/Photoshop and generating a single tile imagery which could be then geo-referenced using the WGS84 coordinate values available in Google Earth or from GPS field observations and this geo coded image could be used as a base map for surveying the study area. Different data collected from the local bodies like cadastral maps, resource maps etc. can be geo-referenced using image to image geo-reference plug-in available in QGIS with respect to the Google Earth imagery and related non spatial databases like questionnaire survey data could be integrated into a common frame work (Figure 5). Different point, line and polygon shape files can be generated using QGIS. Thematic layers can be extracted from the geocoded image like location of individual households, roads, land use, vegetation, new access roads, vulnerable areas including the secondary hazard areas like low lands and creek connected water bodies near to the coast line, risk settlements, shelter proximity and evacuation route. The spatial data thus generated can serve as a great pool of life saving information in times of a catastrophe. This method is a cost effective survey technique for mapping a vulnerable area for developing disaster management and preparedness plans at the local level.

4 Results and conclusions

This paper is an effort to highlight the potential of FOSS GIS tools and technologies in disaster management. Quantum GIS and Google Earth when combined can be used very effectively in disaster management activities. Use of OSGIS is a cost effective method for local level community preparedness and public participatory geographic information sharing, it can be used for organizing mock drills and community preparedness plans. Disaster management plans are to be integrated within the mainstream planning and development activities of local authorities and GIS needs to be deliberately infused into these activities for a better disaster resilient society. The government can develop a crisis informatics unit by implementing this cost effective methodology and can make this system available to all local bodies and by equipping these units with the best technology and crisis informatics available, a high standard of State disaster response team could be developed in a responsible manner.

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Community-based disaster management and public awareness

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ABSTRACT

The paper explains the definition and impacts of disasters, deals with the definition of CBDM, challenges, components and approaches of CBDM. Community-based disaster management programs help to prepare people and respond to disasters and recover from emergencies. The needs for coordination between different government departments, local bodies, volunteers and NGOs with the people are discussed in detail in this section. Vulnerabilities and capacities of the community including vulnerability and capacity assessment, resource assessment and different natures of vulnerability along with community awareness and past experiences are explored. The need to evolve a culture of preparedness among the people through public awareness is also carefully discussed. The strategies that can be adapted during and post disaster situations like rescue, relief, rehabilitation and development with complete participation of community are discussed.

1 Introduction

Disasters are often unpredictable and causes unprecedented catastrophe to the community. This paper aims at highlighting the need for a community based disaster management approach not only for disaster management but in all development programs in order to confront disasters with a holistic approach. The overall awareness of the community on disasters is low despite the fact that certain communities have indigenous knowledge about forecasting disasters and coping mechanisms. The necessity to bring awareness and prepare the community for increased resilience to disasters is the need of the hour. Disaster management components have to be incorporated in development programs so as to mitigate the effects of disasters. This should be evolved as a key strategy for International Governments, NGOs, disaster management professionals, development professionals, community based organizations and other stake holders. In this century lot of development is happening internationally due to technological application in various fields of human development. But due to various environmental and biological reasons disasters are becoming diversely increased bringing huge losses with mankind unable to bring it down. Normally there is an idea that CBDM initiatives are applicable only to grass root level organizations, as the best practices of CBDM initiatives are practiced locally. But these best practices can be disseminated to other parts of the country, regions and world.

This paper is an attempt to bring a broader understanding about disasters, its impacts on various issues and CBDM approaches. The major components of CBDM, like, awareness about disasters, disaster preparedness, early warnings, mitigation measures and management were given emphasis. Greater stress is laid upon the need for community and stakeholder participation at all levels of CBDM and development programs so as to ensure sustainability. The need for assessing the vulnerabilities, capacities of the people, their indigenous knowledge and coping skills for proper planning in order to mitigate disasters and increase community resilience is thoroughly dealt with. Also it highlights the importance of community participation right from planning at various phases to governance issues like policy making.

1.1 Disasters

The word disaster and the concept of disaster management, community based disaster management and need for public awareness on disasters are getting popular as the global community is encountering various disasters in the recent past due to many reasons. "Disaster means an occurrence causing widespread destruction and distress. It is a catastrophe, a calamity, a tragedy, a cataclysm. It is a state of extreme ruin and misfortune which is quite often irremediable. It is indeed a grave misfortune. Disaster is also used to mean a total failure. The word disaster is derived from 'dis+astro' an evil influence of a star", (Udayakumar, 2009). However there needs to be proper counter mechanisms to empower the affected and reduce vulnerability to disasters so as to ensure sustainable development.

1.2 Understanding disasters

The government of India constituted a 31 member committee headed by J.C. Pant in 1999 and the committee in its report identified 31 types of disasters under five categories such as water and climate related disasters, Geologically related disasters, Chemical, Industrial and Nuclear related disasters, Accident related disasters and Biologically related disasters. When a hazard causes massive loss of life and property, it is referred as Disaster. It is a serious disruption of the functioning of a society causing widespread human, material or environmental losses. The loss is such widespread that the existing available local resources cannot fulfill the damage or losses caused by disaster. To minimize the damages caused by disasters, various efforts have been taken by governments, NGOs and international communities including donor agencies. However, in spite of participation of these sectors, it has been observed that many of the disaster management programs have failed to be sustainable at local level after the completion of the particular projects. Without sustainability, disaster management efforts will not protect people during time of crisis. A critical element of sustainable disaster management is community participation in these activities. The most common elements of community involvement are partnership, participation, empowerment and ownership by the local people. The emphasis of disaster management efforts should focus on communities and the people who live in them. Unless the disaster management efforts are sustainable at individual and community level, it is difficult to reduce the losses and scale of the tragedy. There needs to be an opportunity where people can be involved from the initial programming stage of disaster management activities itself. Through these community based activities, people should be able to participate alongside government officials, non governmental agencies and expert groups as the direct stakeholders of these activities. Involvement of communities is important in both pre-disaster mitigation and post disaster response and recovery process (Pandey, 2011).

1.3 Impact of disasters

Impact of disasters varies from place to place. It also depends upon the intensity of the disaster, size of the affected habitation, time of occurrence and so on. It not only affects the life and property, but also affects the occupation of the people, their livelihood, culture etc. It brings Psychological, Economic, Social, Political, Cultural and Ecological impact among the people. Consequence of disasters are injury and sufferings, diseases, starvation deaths, damage and loss of property, disruption of normal life or activities, rise of anti-social activity, loss of livelihood of most people, influence on the basic needs like food, cloth, shelter, health, education and many more.

Psychological impacts: This includes trauma, insecure feeling, negative thoughts, no hope about the future, depression and stress. Disasters leave people with loss of life of dear ones, injury, loss of livelihood, assets etc causing mental agony. In most cases it is the neighbors and relatives who rescue people and extent support instantly. Training volunteers from the community on psychosocial counseling will enable them to contribute effectively during disasters.
Economic impacts: More over communities locate and establish their habitations nearer to their livelihood activity. Often disasters damage life, livelihood, shelter and assets cutting off their source of income. They loose their stocks, assets, capital and source. Resilience to disasters in economic context depends on the traditional knowledge, appropriate skill and availability of resources pertaining to the particular area and activity. Introduction of alternate income generation activities, new and up graded skills, micro to macro market linkages will succeed depending upon the level of participation of the people.
Social impacts: At the strike of disasters there will be break out of epidemics, water contamination, increase in liquor consumption levels, gender discrimination, sexual harassment, lack of basic facilities leading to low social status, dependency, lowered living standard and life style. People have knowledge about relationship of members; who is deprived, how and why; gender issues, role distinction between men and women, housing location etc. They also know types and access of housing and other infrastructures and social structures.
Political impacts: This starts with the question of governance and decision making process. Who decides for whom and why, is the major conflict. While people should own the problems, consequences and challenges of any mitigation or preparedness initiative, it is necessary to take peoples involvement further, into policy and strategy. This process induces sense of ownership to the people which results in their continuous engagement and long term commitment to these activities.
Cultural impacts: Different communities have different practices to share joy and sorrow. There are different traditional cultural activities which enable them overcome stress, express solidarity, gain confidence and enable them to get back to normalcy and quality life. The traditional knowledge associated with weather and

climate prediction practices are based on indicators established over generations through keen observation of plants, animals, birds, insects, the solar system, winds, clouds and lightning patterns. The repertoire of Traditional Knowledge that communities draw on to deal with natural disasters is very large. The communities recognise unique situations associated with the behavior of these living organisms, the location and patterns of cloud, winds, lightning, the sun, moon and stars. The successful application of the knowledge is based on good prognosis, close observation and a thorough understanding of the local environment. The communities are capable to prevent or mitigate disasters. Signs of coming disaster are obvious to everyone and this leads to instinctive response and preparation for coming events. The culture and belief system of a community also influences its response to disaster. The predictions based on these indicators and human feelings support the early warnings issued by the elders to enable the community cope with the anticipated natural hazard. In most communities, disasters were believed to be of supernatural origin and they find themselves handicapped had no power to stop them once triggered but could only mitigate their effects.

Ecological impacts: Disasters often threaten the biodiversity and create huge loss to ecology. It creates heavy loss to forestry, agriculture and also to the agricultural fields. In cases like Tsunami due to inundation of sea water, the nature of the soil gets salinated changing the land uncultivable or less productive. Animals and birds are more vulnerable as the domestic cattle and birds are caged or tied and reared without safety measures. In the Orissa cyclone huge cattle population was buried. Community participation enables to carry out aforestation programs, raise social forestry and conserve ecosystems.

2 CBDM

CBDM is described by the International Institute for Disaster Management as “an approach that involves direct participation of the people most likely to be exposed to hazards, in planning, decision making and operational activities at all levels of disaster management responsibility." The past experiences reveal the fact that the pre and post disaster management strategies can be carried out effectively only with peoples participation and public awareness. Community based disaster management programs helps to prepare people and respond to disasters and recover from emergencies. Coordination between different government departments, local bodies, volunteers and NGOs with the people is a felt necessity.

2.1 CBDM and challenges

The major challenges of CBDM are sustainability of the efforts taken at the community level and incorporation of CBDM issues at the policy level. To be effective and create a sustainable impact, the application of CBDM must go beyond the initiative of local communities, NGOs and a handful of local governments. As part of an advocacy for more responsive and effective governance, central and state level governments should look at integrating CBDM in their policy and implementing procedures. Vulnerability and capacity assessment is a major component in CBDM. Vulnerability is always area specific and is by its nature localized. Hence Vulnerability and capacity assessment should pertain to communities and local situations.

The basic purpose of Vulnerability and capacity assessment is to use it as a diagnostic tool to provide analytical data to support better informed decisions on the planning and implementation of risk reduction measures. It will provide better understanding about the nature and level of risk the vulnerable people face; where these risks come from; who will be the worst affected; what means are available at all levels to reduce the risks; what initiatives can be taken to reduce the vulnerability and strengthen the capacities of the people at risk. While doing so, it will make a clear picture of the vulnerability with context to, gender, age, disability, health status and other local social issues. The process also includes an analysis of patterns of density, livelihood security and occupational activities that increase the vulnerability of certain households and communities. Capacity assessment deals with identifying a wide diversity of resources; community coping mechanisms, local leadership and institutions, existing social capital which may contribute to risk reduction efforts, skills, labor, community facilities, preparedness stocks, local evacuation plan etc.

This process is a kind of participatory partnership and active long term collaboration with local communities in realising their problems and opportunities. It acts as a therapeutic process of self analysis and self-discovery by a community of its latent strengths that will build collective self confidence. Human resource development, resource mapping, to form teams for rescue, first aid, shelter, food, water and sanitation etc and stocking of rescue materials and first aid kits to put in use during times of emergency needs complete community participation.

2.2 Components of CBDM

The major components of the programme is to prepare Disaster Management Plans at appropriate levels, Raising awareness of stakeholders on natural disasters though information and education campaigns, Formation of Disaster Management Committees, Formation and training of task forces with specialized training in villages, Creation of Community Funds, Mock drills to sustain training and mapping activities, Installation of early warning and alternative communication systems, Construction of mounds in low-lying areas and networking of institutions and individuals for effective disaster management.

Preparation of District, Block, and Village level Multi-Hazard Disaster Management Plans, Formation and training of various Task Forces like Search and Rescue, First Aid, Sanitation, Shelter Management, etc. to respond to emergency situations. Enhancing community preparedness to face natural calamities and improving skills for faster recovery after calamities, training and capacity-building of various stakeholders in disaster management. Vulnerability and risk reduction through incorporating disaster mitigation components into existing developmental programmes and planning.

2.3 Approaches

CBDM approaches are initiated to address the causes of vulnerability as part of a broader development effort and to reduce their dependency on outside assistance; mobilize volunteers and target the most vulnerable; increase preparedness of community in consonance with civil society and government response to impacts of disasters; protect and ensure positive socioeconomic development; and reduce deaths and massive destruction of properties.

2.4 Community participation

The active participation of community in planning and implementation will enable them to understand problems and capacities in a reliable and qualitative manner. Also the local communities can easily understand the realities and contexts better than outsiders.

Disaster preparedness covers activities to enhance the ability to predict, to issue warnings, take precautions and facilitate a rapid response and cope with the effect of a disaster. It includes pre-cautionary activities by households, communities and organizations to react appropriately during and following the event. Commonly they are used to categorize the main methods of protecting communities against hazards and disasters. Disaster mitigation and preparedness have tended to fall into the gap between development, cooperation and humanitarian assistance. Disaster preparedness is closely linked to emergency response, whereas mitigation approaches tend to have much in common with developmental processes.

2.5 Sustainability and stakeholders participation

Government Agencies, NGOs, and international organizations implement various programmes both before and after disasters. Most of these are very successful during the project period, but gradually diminish as the years pass. There are many reasons for the gradual decrease of people's involvement in a particular project. The most common elements are lack of partnership, participation, empowerment, and ownership of the local communities. All projects should have very broad stakeholders' participation in order to have sustainability. Stakeholders of a CBDM program can be broadly defined as anyone, individuals or institutions, who may have contributed to the configuration of the disaster management or those who are normally affected by impacts of disasters in a locality, and thus have interest in participating in CBDM.

Under this, section, it is important to establish the extent of social support systems including their roles and contribution by respective persons. The inter linkages of GOs, NGOs, academic and international organizations should be reflected in terms of concrete projects and initiatives, and a model of cooperation should be devised. This also includes, individuals at risks, women's groups; informal and formal leaders at the village level; volunteers with specific roles, such as in warning and evacuation; villagers with specializations like those who are mobilized to protect dikes and masons who can build earthquake-resistant structures; local business sectors, schoolteachers and administrators, district and local government authorities, research groups, people's organization, NGOs, civil societies, technical resource groups, central government, national universities, UN agencies, and international donors. This exhaustive list indicates that for a CBDM to be successful, implementers should be adept in identifying and mobilizing as many stakeholders as necessary. In some countries relationships among stakeholders are formal and legislated, but some cases also show that informal relationships do not hinder partnership arrangements at the community level. It would seem that the choice is dependent on the political structure in a particular country and the perceived level of governance in the area. Experience, however, shows that formal institutional arrangements among stakeholders improve accountability and transparency, which is important for sustainability of CBDM. Likewise, based on the experiences role allocation among stakeholders is highly necessary.

3 Vulnerabilities and capacities

People living in a community have different vulnerabilities and capacities. Some may be more vulnerable or capable than others. For understanding a community, it is important to understand the socio, political, economic, ecological and cultural aspects. Detailed community profiling is the first step of initiating community based disaster preparedness process. We can use simple formats for this purpose which can be devised with the participation of local people taking into consideration the local resources and needs. Understanding the vulnerabilities and capacities is the first step towards community based disaster management. Participatory disaster risk assessment and Risk reduction planning using tools like Participatory Learning and Action have proved to be successful in various disaster management studies.

3.1 Vulnerability and resource assessment

We need to know the priorities of the community members or the most significant problems faced by the community. Learn about the seasonal activities, hazards and disasters. Also to learn what are the significant disaster events that occur in the community. Identify areas at risk from specific hazards and the vulnerable members of the community. Identify available resources that could be used by community members in disaster risk management. Get a clear picture of vulnerability of the community and the resources that are available or may be available for disaster risk management. Also to learn about the history of disasters in the community, the factors that led to the disasters and the impact on the environment and people's lives and to find out how much natural resources have been affected by disasters and how much more could be remaining. Determining the hazard that has the most serious impact on the community and to determine the most critical facilities at risk are of priority.

3.2 Nature of vulnerability

Vulnerability differs, with accordance to areas, as in Bangladesh, where vulnerability is perceived to be a complex interaction between, unsafe conditions, poverty, lack of access to resources, landlessness, societal pressures, inequity, lack of education and other underdevelopment Causes. In Cambodia, the agency involved in CBDM project put emphasis on food shortages, and the vulnerability of the means for food production. In India the peoples lives, property and livestock are considered most at risk as a consequence of the super cyclone that hit the State of Orissa in 1999. In Nepal and Indonesia, the emphasis is laid on the vulnerability of physical structures, particularly school buildings vis-à-vis the effects of major earthquakes.

3.3 Community awareness

We must realize the fact that individuals, households and communities are generally unaware of the extremities of the hazards they face despite the indigenous knowledge they posses. They underestimate dangers while overestimating their ability to cope with any crisis. They also tend not to put much trust in disaster reduction strategies, and rely heavily upon emergency assistance when the need arises. Public awareness includes development and wide distribution of educational booklets, posters, guidebook and mock drills for disaster preparedness and response. The guidebooks can be subjected to periodical verification and updated through trainings and mock drills. The United Nations Centre for Regional Development (UNCRD) has promoted School Earthquake Safety Initiative through a project "Reducing Vulnerability of School Children to Earthquakes" jointly with UN Department of Economic and Social Affairs (UNDESA) in Asia-Pacific region. The project aims to make schools safe against earthquakes and build disaster- resilient communities through self-help, cooperation and education. The project includes retrofitting of school building in a participatory way with the involvement of local communities, local governments and resource institutions, trainings on safer construction practices to technicians, disaster education in school and communities. This idea must be replicated while the local bodies and government departments carry out constructions, so that it will make aware the general public about the need for disaster resilient buildings.

3.4 Past experiences

When we look at 2004 Tsunami, in Kanyakumari district, Colachel village, where nearly 700 people died, people who were breathing to life, who got stuck in the cannals were not able to be rescued despite the fact that almost all the fishermen know swimming. They were unable to organize themselves and involve in rescue operation. Similarly the helplessness of the district administration in coordinating the various government departments was so obvious, when it got stuck with lot of hurdles in delivering rescue and relief measures. But studies reveal that in countries where CBDM has been successfully implemented, communities were able to organize and act quickly due to the presence of trained volunteers who were aware of the actions that needed to be undertaken.

4 Strategic planning

Community based disaster management needs effective planning, so that it can be ensured through true community participation and awareness. Community Based Organisations, local bodies and other participating agents need clear vision, management capacity, adequate knowledge, information and true spirit of facilitation which are fundamental for the success of CBDM. Legal status of Community Based Organisations, linkages with other development initiatives, Integration of gender needs and womens participation and empowerment are vital. Ensuring community contributions to the project and provision of resource generation at the local level will enhance the partnership and ownership tendency of the people. It is recognized from various programs that the local government is the best positioned to provide leadership integrating disaster management with long-term development. Locally appropriate coping mechanisms among the community should not be are ignored; while planning for enhancing capacity of the community, outside organizations must learn the existing coping mechanisms and how to improve them. CBDM will initiate a community level process of community participation, empowerment and problem-solving mechanism undertaken by a community to prepare for, and respond to, the natural disasters that may affect them. It involves addressing or decreasing their vulnerabilities and increasing their capacities to deal with the natural disasters that frequently occur.

It was evident from the Gujarat earth quake and 2005 Tsunami that in all the phases like rescue, relief, rehabilitation and development met with failures, when ever, the particular initiative was not community based. Even many houses constructed were not occupied by people because they were not involved in the planning process and the implementing agencies forgot to take their livelihood options and operational area while finalizing their new habitations.

***R*escue**: Rescue operations are initiated immediately after the occurrence by the neighbors and relatives willingly or unwillingly because they are the ones living among the community. They also have traditional knowledge, courage and in some cases experience to react to such situations without expecting or waiting for external support. CBDM approach enables them to acquire more skills, commitment, sense of responsibility and also stocking of rescue materials.

***R*elief**: During Relief Phase, the immediate needs of the people have to be carefully identified. This includes a wide variety of activities such as medical assistance, supply of essential commodities, utensils, clothing, water supply, sanitation, shelter facilities, psychosocial counseling and the like. Identification of people who really needs to be supported, assessment of their losses, ensuring no social exclusions are few major components which need community participation and cooperation.

***R*ehabilitation**: Rehabilitation Phase starts with restoration of lost livelihood activities and exploration of possible traditional and alternate income generation activities. Many project driven livelihood activities initiated have ended up with loss and failed to sustain as there were no participatory planning at the initial stages. Successful livelihood initiatives needs human resource, availability of raw materials, skill, market demand, willingness for; acquiring skill up-gradation, enhancement technical knowledge through trainings, entrepreneurship etc.

***D*evelopment**: Development Phase involves long term initiatives and projects and should have vision, mission and objectives. Community involvement is absolutely necessary for the sustainability of these projects.

5 Conclusion

The methods for participation and empowerment that seek to sustain and institutionalize the process are, use of participatory approaches (PRA/PLA) involving communities in hazard; vulnerability, capacity and resource assessment as a basis for community planning; formation of informal organizations which would represent the community in coordination activities with formal local authorities; institutionalizing mechanisms such as a formal committees or councils with legal tie-ups with local government authorities; sustained public awareness involving all major stakeholders; and the community's active involvement in almost all phases of development from planning, monitoring, and evaluation. Most of the projects under study promote tangible accumulation of physical and economic assets to reduce vulnerability. These are in the form of village contingency funds, and availability of credit for income generating activities, micro-solutions, small and medium-scale infrastructure projects that reduce impact of hazards; equipment and materials such as for latrines, water supply, early warning systems, rescue and evacuation facilities. Some focus on providing intangible "assets" such as technology in disaster resistant construction and access to information centres. Successful CBDM ventures have resulted in, increased willingness of individuals to work for a common purpose; use of collective action to solve community problems and decreased dependence on external assistance; increased awareness of possible individual and community disaster preparedness measures; and inculcation of positive attitudes among villagers in terms of their abilities to initiate changes towards the improvement of their communities. Risk Management (IDRM International) as an approach that involves direct.

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Analysing the earthquake vulnerabilities for urban areas: In the context of Chittagong city

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ABSTRACT

The historical seismicity along with recent seismic activities of Bangladesh indicates that our country is at high seismic risk. Earthquake has a great impact on urban areas rather than rural areas. The existing urban trend and urbanization process of Bangladesh, increases vulnerability to natural disasters like earthquake through the unplanned urbanization & high concentration of people and assets. The increasing urban risk results in vicious circle of disasters affecting urbanization and urbanization affecting disasters. The risk in urban centre is compounded due to unplanned urbanization, development in high risk zones. This paper interprets the urban vulnerability for earthquakes based on existing physical environment. Chittagong city — one of the major urban areas in Bangladesh, experiencing physical vulnerabilities like, informal or unplanned settlements, poor infrastructures, existence of vulnerable built environments and so on. Rapid urban growth is causing deterioration and increasing the vulnerability of human lives, economy and infrastructures. If a strong earthquake hit the Chittagong city which may result damages and destructions of massive proportions and may create disastrous consequences for the entire country. This paper aims to analyze the issues related to physical urban vulnerability in detail to arrive at strategies or policy based solutions that are necessary to support the redevelopment of urban areas like Chittagong. By combining this vulnerability assessment of Chittagong city, this paper tries to give some strategic guidelines for the utmost use during disaster.

1 Introduction

1.1 Geological characteristics and historical earthquakes in Chittagong

Chittagong is located in the Tripura–Chittagong Fold Belt (Alam *et al.*, 1990), where a thick sedimentary sequence deposited through Tertiary to Pleistocene age, which have been folded during the Himalayan organic movements. During this long geological time the area has experienced a varied environment due to the transgression and regression of sea. The area occupies most of the plunge area of Sitakunda Anticline and the plunge area is cut by Sitakunda fault, Tiger Pass fault and Karnaphuli fault (Figure 1) *(Mominullah, 1978)*. It is also observed that the older sediments are severely jointed and fractured indicating dissipation of accumulated energy. According to the Global Seismic Hazard Assessment Programme (GSHAP) (Chittagong division is the most hazardous division in Bangladesh. Maximum peak ground acceleration (PGA) may be expected to be in the range of 0.24–0.48 g. The present geological condition indicates that the area is located in a zone where possibility of occurring earthquake is very high. Chittagong has a long history of earthquakes. There are hundreds

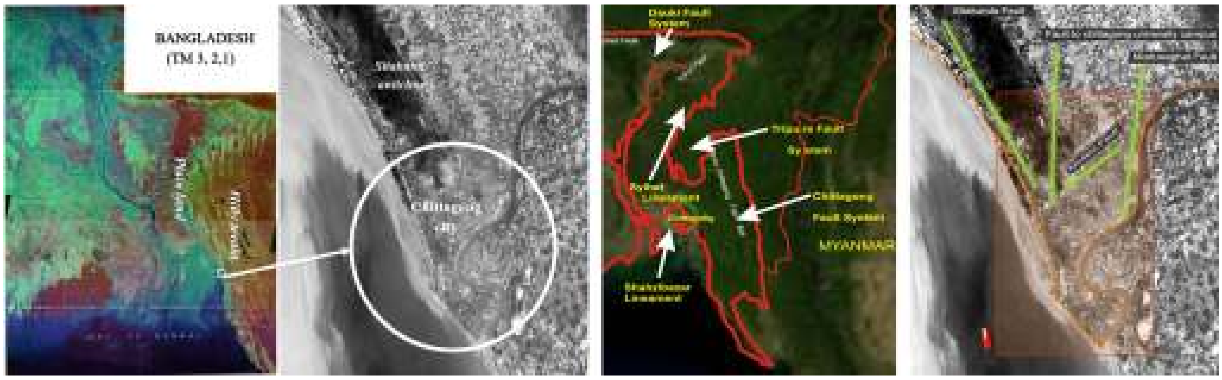


Figure 1. (a) Bangladesh in lands at TM bands 3, 2, 1 mosaic image of Bangladesh (Khan, 2006); (b) IRS-1D panchromatic image of Chittagong and surroundings (CEGIS, 1999); (c) & (d) Different fault locations in and around of Chittagong city.

of evidences of earthquakes that jolted Chittagong and its surrounding areas (Sharfuddin, 2001). One of the largest earthquake in history occurred in 1762 near Chambal in the southern part of Chittagong division. Although the intensity could not be recorded at that time but it caused heavy damages. It triggered the earliest documented tsunami in the Bay of Bengal. Another big earthquake occurred in 1869 with an intensity of 7.5 M near Sylhet. This was also strongly felt in the whole Chittagong division. The Bengal earthquake in 1885 was also very strongly felt in Chittagong. Bihar–Nepal earthquake (8.3) and Assam earthquake (8.5) in 1950 was also felt in the city and its surrounding areas. If we look at the recent time we find that since 1996 till to date, the Chittagong region, close to Myanmar border, has experienced more than 200 light and moderate earthquakes. Banripara Indo–Bangla border earthquake occurred on 8th May 1997 with a magnitude of 6 M. It was felt mainly in Chittagong and also in Rangpur, Sylhet and Meghalya. In the same year on 21st November another earthquake took place of the same magnitude, which was named as Chittagong Indo Bangladesh Border earthquake. This quake was felt throughout the country. But Chittagong had the most destructive effect. About 23 people were killed and one five storied RCC building collapsed in this incident. On 22nd July 1999 another earthquake of moderate magnitude of 5.2 M took place in Moheshkhali Island of Chittagong division. This quake was followed by few aftershocks and caused widespread damage in which at least seven people were killed and more than five hundred were injured. Cracks were developed in the concrete structures of cyclone shelters and there was considerable damage of mud houses.

1.2 Research problem

Chittagong, the biggest port city of Bangladesh grows on an area of 155 Square kilometers with varying population density in its different parts. Present population of the city is about 6 million; in 2001 the population was 3.36 million and it was 1.39 million in 1981 *(Wikipedia, 2007)*. To cater the demand for housing for the growing population, the town expanded in every possible place, even to the depressions after filling it up. Large-scale catastrophes from urban disasters have been graphically and tragically demonstrated in the recent years. As Chittagong is the most important trade centre for Bangladesh, the loss would be unimaginable if a large earthquake strikes the city. Bangladesh is a densely populated country. Through incapability and reluctance, failure to plan development in the poor and disaster prone country like Bangladesh will result in greater exposure to natural and manmade hazards for large number of people. Due to unplanned urbanization & rapid growth of its urban centres, Chittagong city has became the most vulnerable to probable earthquake threat. The best suitable zones around Station Road, Reazuddin Bazaar, Jubilee Road, Diwan Bazaar and Dampara areas area already occupied by unplanned dense settlements. Even before the last two decades people had the choice to stay around these places but presently due to its rapid development men have to move and live in the hazardous areas like Pachlias, Chandgaon, Agrabad, Nasirabad, Pahartali and Halishahar. Though hilly areas are hazardous due to its association with landslide or mass movement and slope instability, but people are making it flat by cutting hills for mostly residential & commercial uses. Flat areas are hazardous because of low bearing capacity of soft soil deposit, which is very much susceptible to liquefaction. If there is a moderate vibration, it may cause massive landslides and those structures resting at the foothills will become simply death traps for the dwellers. But what Chittagong city makes most vulnerable against earthquake is the biggest unplanned development, haphazardly distributed throughout the whole city.

1.3 Objective of the research

This research mainly focuses on the issues related to earthquake vulnerabilities in a dense urban fabric. The study focuses on the physical urban vulnerable elements for earthquake hazard especially for existing unplanned urban areas in Chittagong city. It attempts to find out the problems and analysis the risk associated with informal urban settlements. Hence the main objective of the study is to understand the seismic hazard in the study area and importance of land use planning with seismic microzoning map. Finally identify the urban physical vulnerable elements which may create disaster situation during and after earthquake.

1.4 Study area

Chittagong City is located in the south eastern part of Bangladesh having the coast of the Bay of Bengal in the West Karnaphuli River in the East and South, and the Sitakund anticline in the North. The City lies between longitude 91°45′0″E and 91°54′0″E and latitude 22°14′34″N and 22°24′39″N. Dimension of the city is rather triangular, guided by the river course, with 16 kilometers in east–west and 18 kilometers in north–south. Chittagong is situated in the eastern hilly part of Bangladesh; this region is characterized by a north–south trending folded mountain range, which is quite different in terms of topography from the rest of Bangladesh that is consisting of river flat plain.

2 Theoretical perspectives

2.1 Urban vulnerability to earthquake hazard

Earthquakes are the most deadly of the natural disasters that may affect the human environment. About 60% of world-wide casualties associated with natural disasters are caused by earthquakes (Coburn & Spence, 2002). Urban vulnerability to natural hazards such as earthquake is a function of human behavior. It describes the degree to which socioeconomic systems and physical assets in urban areas are either susceptible or resilient to the impact of natural hazards. Over the past two decades, vulnerability has come to represent an essential concept in hazard research and in the development of mitigation strategies at the local, national, and international levels (White & Haas 1975, Hewitt 1997, Mileti 1999, Alexander 2000). Several models of urban vulnerability have been proposed to address the various ways by which society becomes subject to hazard impacts (Cutter 1996, Menoni & Pergalani 1996, Menoni 2001). Urban vulnerability is an inherently spatial problem since it almost always deals with communities within a defined urban space. The implications of the type of problem-solving methodology for urban vulnerability analysis are limited because many concepts, rules, and principles associated with vulnerability in cities are not sufficiently certain, nor are all the elements and processes contributing to it acknowledged or articulated. Vulnerability defines the inherent weakness in certain aspects of the urban environment which are susceptible to harm due to social, biophysical, or design characteristics, whereas risk indicates the degree of potential losses in urban places due to their exposure to hazards and can be thought of as a product of the probability of hazards occurrence and the degree of vulnerability (i.e. risk=hazard X vulnerability) (UN, 1991). Urban earthquake risk today derives from the combination of local seismicity combined with high dense built environment, informal settlement or unplanned development in urban areas, large numbers of poorly built or highly vulnerable dwellings, poor infrastructure, contiguous building character, lack of proper land use planning against hazard zoning, etc.

2.2 Earthquake vulnerability reduction for cities (EVRC)

Earthquake Vulnerability Reduction for Cities (EVRC) is a concept of action has developed to ensure safety of human lives and reduce losses from earthquakes that may occur tomorrow. Some studies are established the topic 'Vulnerability Reduction for urban areas due to earthquake hazard' as 'Urban Earthquake vulnerability Reduction' (ADPC, 2003). There are a wide variety of ways to facilitate risk reduction or earthquake vulnerability reduction and rapid post-disaster recovery. Regulatory and legal measures, proper land use policy, metropolitan disaster prevention plan, policy based design solution & proper implementation, improved analytical and methodological capabilities, financial planning, political commitment, institutional reforms, etc are the options for risk reduction. Urban Disaster Prevention Project was initiated by bureau of city Planning Tokyo Metropolitan Government. This initiated lots of Countermeasures to reduce the earthquake vulnerability for urban areas.

2.3 Options for vulnerability reduction

In order for a community's risk management measures and regulations to be effective, the community must integrate risk assessment with risk management, choosing specific measures or regulations having a benefit/cost of at least one to eliminate or reduce perceived vulnerabilities in the built environment. Every community at risk from earthquakes has many proven and cost-effective options available to it to reduce its perceived unacceptable risk. Each option carries a cost and an expected benefit. Because risk is not static-changing over time as the-level Of understanding of earthquakes and their consequence increases risk management requires a long-term investment of resources to realize the greatest benefit/cost.

2.4 Vulnerability assessment tools

Several loss estimation models are available as candidates to serve this purpose and many of them use GIS software and scientifically developed algorithms to calculate, map, and display damage and loss estimates according to particular scenarios, which assess the vulnerability. Examples of these models include: HAZUS (HAZards in the US; http://www.fema.gov/hazus/), RADIUS (Risk Assessment tools for Diagnosis of Urban Areas against Seismic disasters; http://www.geohaz.org/ radius/), EPEDAT (Early Post-Earthquake Damage Assessment Tool; http://www.eqe.com/), ROAD-1 Seismic Analysis Software (http://mceer.buffalo.edu /research/HighwayPrj/), and RiskLink-DLM (Detailed Loss Module; http://www.rms.com/).

3 Earthquake vulnerabilities in the context of Chittagong city

Chittagong city, one of the major urban areas of Bangladesh, experiencing earthquake vulnerability like high population density, high building density, informal or unplanned settlements, non engineered buildings and shelters, large number of poorly built buildings, contiguous building pattern and lack of open spaces add up to the problem. Unplanned growth and land use planning without hazard zoning of city increased the vulnerability of human lives, economy and infrastructures.

3.1 Land use pattern of Chittagong city

Chittagong City Corporation is an autonomous local government, consisting of 41 wards. It is a very hectic city with a lot of industries, refineries, cargo shipment activities etc. The northern central part is hilly and sparsely populated, and mostly covered by the cantonment area (army). The most densely populated area is the southern part between hilly area and the Karnaphuli River followed by eastern and western part. Extensive industrial areas are located in the east and western part. Different land use categories are shown in Figure 2 (Sharfuddin, 2001). It is obvious that large unplanned residential areas, commercial and industrial areas and especially hilly areas are most vulnerable due to earthquake hazard. There is no combination between land use pattern and the proper seismic microzonation layout.

Category of land use	Land used (Acres)
Planned residential areas	1961.45
Unplanned residential areas	10378.62
Commercial areas	988.40
Industrial areas	3243.30
Cultivable land areas	10996.40
Hilly areas	5930.64
Tidal areas	2594.60
Unclassified areas	1899.70
Mixed areas	556.00
Other areas	926.65
Total	39475.76

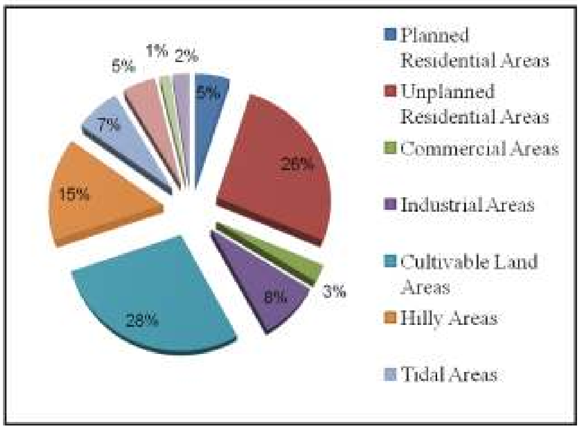


Figure 2. Land use diagram of Chittagong City.

3.2 Physical vulnerability in existing built environment

The most part of the city is characterized by a high density of population living in a very compact land area with close proximity of buildings along a very narrow local street (Figure 4). In most cases it is difficult to differentiate the buildings from each other. The existence of physical vulnerability is categorised in various way. From the survey, the identified threats are unstable masonry boundary wall, poorly fixed street signs, many other dislodged item, complex building configuration, horizontal and vertical irregularity, soft stories in most of the residential buildings, etc (Figure 3). The situation during an earthquake will be multiplied many more times.

4 Recommendations and conclusion

4.1 Solutions for sustainable land use planning with seismic microzoning map

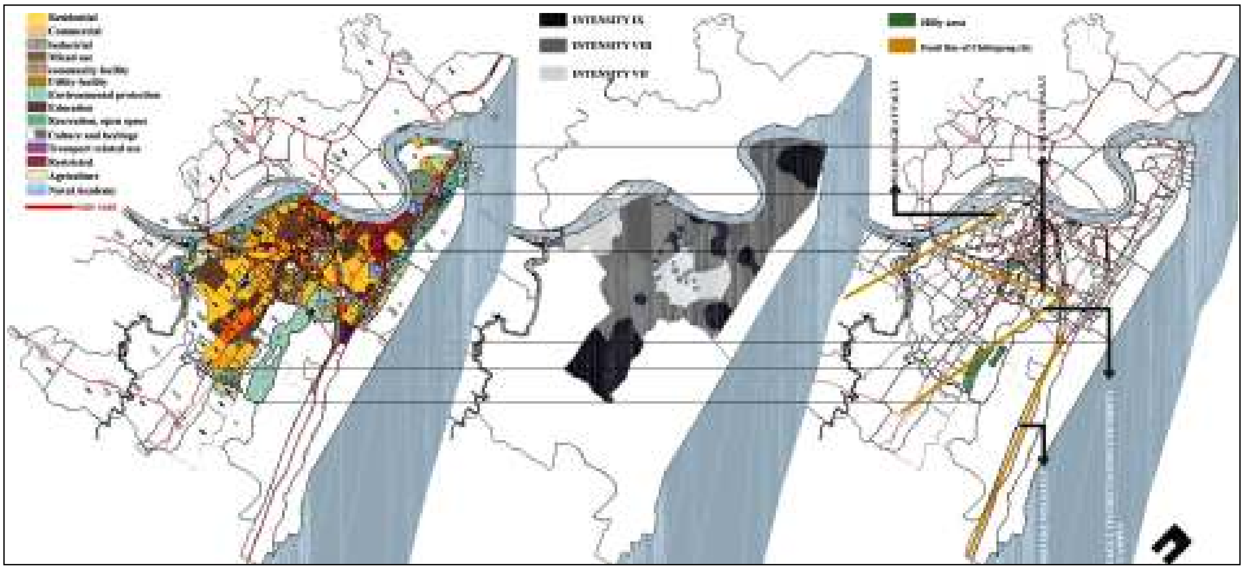
The land use pattern and the physical development of the built environment all affect the consequences of an earthquake. The linkages between land use master planning for earthquake protection and other urban planning protection measures and the control of building quality are so interrelated that the professionals whose are the responsible for the development of effective earthquake protection measures should establish a strong coordination between them at the very beginning. The whole procedure may divide into three layers. They may be termed as above surface, surface and subsurface. First one is land use of the city and last two cover the seismic microzonation of the geological earthquake hazards. By combining the three layers we can plan to shape a safer city (Figure 5). After analyzing the three layers, it may be possible to avoid building on some areas of potentially higher hazard zone. This zone might be left as park areas or dedicate as green belt for the recreation of city dwellers. By building on areas of potentially lower hazard, future earthquake damage and loss can be reduced.

4.2 Seismic Vulnerability map of the buildings of the city and earthquake prevention plan for urban areas

Earthquake protection needs information on construction materials, building height and size, building configuration, structural outline, engineering design quality, age and other indicators which are related to seismic vulnerability. Vulnerability assessment by detailed methods must be conducted for preparing seismic vulnerability map because this map encompasses the physical attributes of the building stock. To create a city for

Figure 3. Photographs of the existing physical vulnerabilities of Chittagong city which may create devastating situation during disaster.

Figure 4. Showing the density by a section of Nondon Kanon area of the Chittagong City.



(a) Land use planning (CMMP, 2007); (b) Seismic hazard zonation map (Sharfuddin, 2001); (c) Fault locations (Mominullah, 1978) of Chittagong City

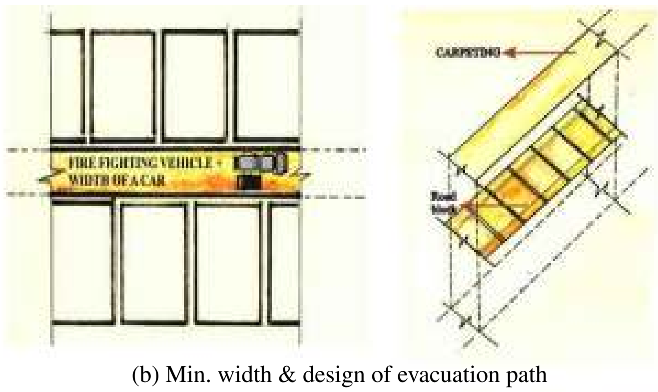
Figure 5. Procedure of preparing land use planning for a city considering earthquake hazards. (a) Land use planning (CMMP, 2007); (b) Seismic hazard zonation map (Sharfuddin, 2001); (c) Fault locations (Mominullah, 1978) of Chittagong City.

the 21st century, every city should have earthquake prevention plan. Under this prevention plan there would be numerous countermeasures for earthquake vulnerability reduction in city.

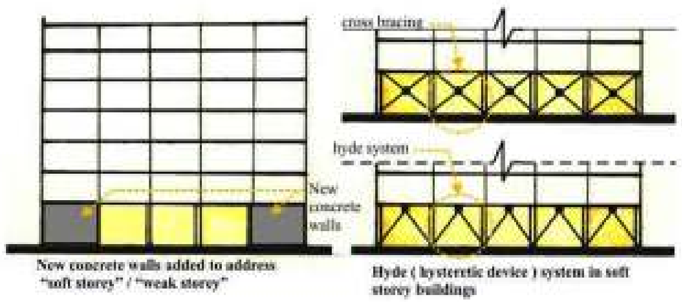
Countermeasures for earthquake prevention plan:

An evacuation path or an emergency exit route should be designed in a highly dense urban area especially for those which have been identified as earthquake vulnerable zone (Figure 6a). This emergency path should lead towards or connect the major open space and public buildings thus it could be used as post disaster shelter. Any water body or any source of water should be a part of this emergency path due to after earthquake fire hazard. Evacuation path of a particular area will be selected in a way such that it will be the most convenient to use as the exit route for the people experiencing an earthquake. Every evacuation path will be led to a predefined safe evacuation centre. Length of path should be as small as possible. An evacuation path should have a minimum width all the way through. In general, the minimum width = Fire fighting vehicle width + car width (Figure 6b). If the existing width of the proposed evacuation path is less than the required minimum, then the structures on the besides of the path may have to be destructed to increase the width. As these paths should

(a) Emergency evacuation path



(b) Min. width & design of evacuation path



(c) Retrofitting soft storey effect

Figure 6. Proposals for earthquake prevention plan in an urban area. (a) Emergency evacuation path (b) Min. width & design of evacuation path (c) Retrofitting soft storey effect.

be free from all kind of damage, building adjacent to this road should be earthquake resistant. Special measure should be taken to retrofit the vulnerable one or destroy the most risky built form. It should be designed as such that all lifeline facilities those go beneath the street should be after earthquake and least damage will occur. Roads should be designed in a segmental manner (Figure 6b). Thus damaged portion can easily be replaced after disaster and a simple crack can't hamper the whole path during disaster. Again, utility pipes should be innovatively designed through using damper. For better action after earthquake, this path should be free from all kind of damage related to disaster, thus building adjacent to this road should be earthquake resistant. Boundary walls should be designed as such that it not only ensure privacy and security but also reduce the risk of being collapsed or creating hazards during disaster period. Closely spaced building should be retrofitted by making all the building at same height thus they will shake as a single unit during earthquake. To prevent soft storey effect in existing building proper retrofitting measures should be taken (Figure 6c).

4.3 Conclusion

The only solution to earthquake hazard is a tangible and long-term plan to refurbish the unplanned part of the city and remove the hazards that its residents are being exposed to every day. This study tries to assess the prevailing condition in unplanned part of Chittagong city and tries to depict the condition what may happen if an earthquake occurs. Finally an intensive literature survey has been helped to establish countermeasures for minimizing earthquake disasters. Thus in unplanned urban areas, vulnerable elements should be identified & assessed to establish guidelines for reducing after earthquake losses & causalities. Addition of seismic micro zoning map in preparing land-use plans or development master plans for fairly straightforward & comparable study maps that will contribute to the planning process (Coburn, 2002). On this regard, different multiprofessionals should work together to built a safer city.

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Response of international charter 'space and major disasters' to major disasters

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ABSTRACT

Space-based Disaster Management Support System has the distinct advantage of being unaffected by disasters on the ground and provides unbiased, synoptic and timely information for efficient management of disasters. Indian Space Research Organization has developed several applications/programs and techniques using space systems to support disaster management. Further, ISRO is a signatory to the International charter 'Space and Major Disasters' along with space agencies of Canada (CSA), Europe (ESA, CNES, DMC), USA (USGS, NOAA), Argentina (CONAE), Japan (JAXA) and China (CNSA). Recently space agencies of Germany (DLR) and Brazil (INPE) have joined the Charter and are in the process of getting integrated into Charter operations. International charter 'Space and Major Disasters' is the maiden initiative of this kind, in which, space faring nations formally participate to pool their space and ground segment resources and deliver data in emergency situations.

This paper brings out the objectives of International charter 'Space and Major Disasters' its operational organization, support mechanism and application for major disasters such as Flood, Cyclone or Hurricane, Forest-Fire, Volcano and Oil-spill. ISRO plays an active role in the charter functioning by sharing Secretariat, Emergency on Call Officer and Project Manager Support services. A brief account of ISRO's participation in the charter operations is provided. Charter has been active since 2000, providing useful service to humanity during major disasters all over the globe. Performance of the charter thus far, with illustrative case studies of selected charter activations is included. The kind of response the Charter received from the user agencies from all around the world once again established its significance and role for major disasters and its wider user base.

1 Introduction

Space-based disaster management support system provides valuable inputs in disaster management, when appropriately integrated with the conventional ground based systems. Interestingly, space based system is the one which remains unaffected by the very disaster on ground and provides unbiased, synoptic and timely information on the nature and the impact of the disasters. Space inputs are useful in taking appropriate preventive measures through hazard zoning and apriori risk assessment at local and regional levels. It is also well proven that space based weather forecast and advance warnings of severe weather conditions facilitate timely and effective rescue, relief and rehabilitation of affected population. Earth observation satellites facilitate imaging of the disaster-affected areas and help to assess the extent of damage of the affected areas. This vital information helps in initiating relief measures and allocation of suitable resources for rehabilitation.

As a part of promoting the use of Space data systems, Indian Space Research Organization (ISRO)/Department of Space (DOS) has developed several tools/techniques in the past two decades to support disaster management for various disasters such as flood, cyclone, tsunami, landslide, earthquake, forest fire and drought. ISRO, as a party to International Charter 'Space and Major Disasters', is playing a key role in integrating space inputs for global disaster management. This paper provides a brief description of Charter functions, organization and operations. The performance of the Charter over 10 years of its operations is highlighted with case studies.

2 International charter space and major disaster's

During an emergency, the challenge is to obtain quick and clear view of the situation. From their orbits, satellites provide images of wide areas in one pass, with a precision of a few meters for IRS and SPOT. By virtue of Radar instruments, ENVISAT and RADARSAT-1 can image the surface of the earth night and day in all weather conditions. Comparing images acquired after a disaster with earlier one allows for the detection of the areas, where changes have occurred. This is vital information for the civil protection authorities, which has to rescue the people and restore the services. Today, the speed with which we can deliver the products is limited by how quickly a satellite can be put to vantage position to image the disaster.

Considering the potential contribution that space can provide in case of major disasters, it was during the UNISPACE-III conference of July 1999, the space agencies of France (CNES) and Europe (ESA) proposed the creation of a Charter for cooperation, which they later signed along with the Canadian Space Agency (CSA) on October 20, 2000. The International Charter was declared formally operational on November 1, 2000. Subsequently Indian Space Research Organization (ISRO) and National Oceanic and Atmospheric Administration (NOAA) joined the Charter in September 2001. Argentina Space agency (CONAE) joined the Charter in July 2003. In July 2003, UNOOSA also joined the Charter as cooperating body, which would act as a gateway for submitting requests for assistance from UN agencies. Later United States Geographical Survey (USGS) and Space Agency of Japan (JAXA) joined the Charter in 2005. Recently, in 2007 Chinese Space Agency joined the Charter.

The Charter requires the space member agencies to cooperate in providing data, information and services that will supplement/complement the needs of the states and communities in emergencies caused by disasters. The basis of such cooperation is voluntary, and the cooperating agencies of the Charter exercise their best efforts to fulfill the obligations towards the Charter and make available their space and associated ground resources for data acquisition and delivery. The Partner agencies participate in the Charter without the need or obligation to expand their resources or incur any additional expenditure. Their participation does not prevent them from providing data on their own to the users. The Charter is open to other space data and service providers for membership and contribution to Charter objectives. The requests for assistance in situations of Emergency can be received from an Authorized User (AU) under the Charter. Other bodies, such as international organizations of humanitarian assistance and environmental management, can also request the data through authorized users.

2.1 Primary goals: International charter

In promoting cooperation between space agencies and space system operators in the use of space facilities as a contribution to the management of crises arising from natural or technological disasters (Anon, 2001), the Charter seeks to pursue the following objectives:

- Supply, during periods of crisis, to states or communities — whose population, activities or property are exposed to an imminent risk, or are already victims, of natural or technological disasters — data providing a basis for critical information for the anticipation and management of potential crises.
- Participation, by means of this data and of the information and services resulting from the exploitation of space facilities, in the organization of emergency assistance or reconstruction and subsequent operations.

2.2 Charter implementation and operations

A Charter Board comprising representatives from all agencies oversees the functioning of the Charter and provides policy guidelines. The administrative, operational and technical coordination is provided by Charter Executive Secretariat, formed with one representative per partner agency. The Secretariat functions on e-mail network, one agency serves as 'primes pares' or nodal point (by rotation) coordinating the activities for a period of six months. Periodic teleconferences are held to discuss operational and technical problems and to resolve issues. Secretariat is also responsible for evolving the operations procedures, guidelines and documents as well as monitoring system operations and performance.

In the event of a major disaster, an Authorized User (AU)/Cooperating Body in the Charter list can activate the Charter by contacting a 24-hour operator, with functional designation as On-Duty Operator (ODO) in Frascati, Italy. Once a call is received accompanied by User Request Form (URF) and validated by the ODO, the latter notifies an Emergency On-Call Officer (ECO). The ECO develops a plan of action surrounding the event. The functions of an ECO are ensured by each of the Partner Agencies on a weekly rotational basis. A calendar of the weekly ECO assignment is updated and kept with the Executive Secretariat, and is distributed among the Partner Agencies regularly. After completing the procedures for data acquisition for covering a disaster, the ECO passes on the plan of action to a designated Project Manager (PM), who is qualified in data handling, analysis and application, and assists the user throughout the process. The PM ensures data interpretation/analysis and prompt delivery of the data products and analysis reports to the users according to their requirements. Figure 1 represents the block schematic of Charter operations. The space resources committed by the Charter Partner Agencies (PAs) include optical and microwave sensors of different resolutions and swaths.

Figure 1. Charter operations cycle.

2.3 Charter activation criteria

A request for covering a disaster event is generally met by planning a new acquisition and/or ordering data from the archives. The following criteria will apply in accepting the request.

The request received from an Authorized User is validated for compliance with Charter objectives and analyzed within the framework of the definitions provided and the scenarios established for various types of disasters. The charter activation is approved only after consensus agreement among Secretariat members. The Charter is activated exclusively for an emergency involving major disaster. Data requests intended for research and development into disaster management or similar applications are not entertained. The sustained monitoring of disasters such as drought, tracking oil spill and epidemics does not constitute a case for Charter activation. The Charter can be activated against major disasters such as Earthquakes, Floods and landslides, Storms or Hurricanes, Forest Fires, volcanoes and Oil Spills.

3 ISRO's participation in the charter

ISRO, as a signatory to the International Charter has become an integral part of the global efforts on disaster management. ISRO offers imaging services through its operational Indian Remote Sensing fleet of IRS-1D, IRS-P4 and IRS-P6, employing all their sensors.

Towards supporting the International Charter by providing timely data and inputs as required, ISRO has established an internal structure consisting of representatives for the Charter Board, a member for the Executive Secretariat, Emergency on Call-Officer, Project Managers (PMs) and Communication Engineer in key themes. (See www.disasterscharter.org/home).

3.1 ISRO as authorized user for charter activation

Considering the active role played by ISRO in developing and establishing remote sensing applications for disaster management, it was decided that in the initial phase of Charter operations, ISRO would take the responsibility of being the Authorised User (AU) for India and coordinate with the Central and State Governments to activate the Charter, whenever the need arises. ISRO as a part of the programme on Disaster Management Support (DMS) established a Decision Support Center (DSC) that would be networked to the Central and State Government systems. Query based services will be provided on various disaster related aspects. This would lead to capacity building in the State Governments to use space-based information. Central and State authorities in India and outside may seek Charter support for disasters defined within the scope of the Charter, through ISRO.

4 International charter for rescue of global disasters

The Charter has been activated for 280 times as on January 31, 2011, covering all the continents for all types of disasters. So far, the Charter has been activated for 180 cases of floods/hurricane/typhoon/cyclone; 38 times for earthquakes; 15 times for oil spill/accidents, 17 times for volcanic eruption, 17 times for forest fires, 11 times for landslides, and 2 times for snow/ice related disasters. Presently, the Charter is activated, on an average, once in 3 weeks, and the frequency of activation has increased with UNOPS joining the Charter as cooperative body.

The following are highlights of some of the Charter activations:

Bam Earthquake: The Bam earthquake in Iran was the most dramatic event in 2003 in which about 20,000 people were killed. A number of European rescue teams flew to Bam and for the first time some cooperation and briefing of activities took place under European Civil protection banner. France, Germany and Portugal activated the charter simultaneously. Further UNOPS & IRAN requested for the data. Two hazard zone maps of Bam earthquake was derived from the fusion of IRS-1C, SPOT (CEOS 2005) and Ikonos satellites data as given in Figure 2. These maps were widely used in the relief operations. Also, pre-event IRS-1C data from the archives was found very valuable.

Asian Tsunami: A high-magnitude earthquake, 9.0 on the Richter scale, struck southern Asia at 00:58 UTC, 6:58 AM local time on 26 December 2004. The epicentre was 320 km west of Medan, just off the west coast of the Indonesian island of Sumatra. The earthquake was followed by tsunamis that killed nearly a quarter of a million people, mostly in Indonesia, Sri Lanka, and India. The

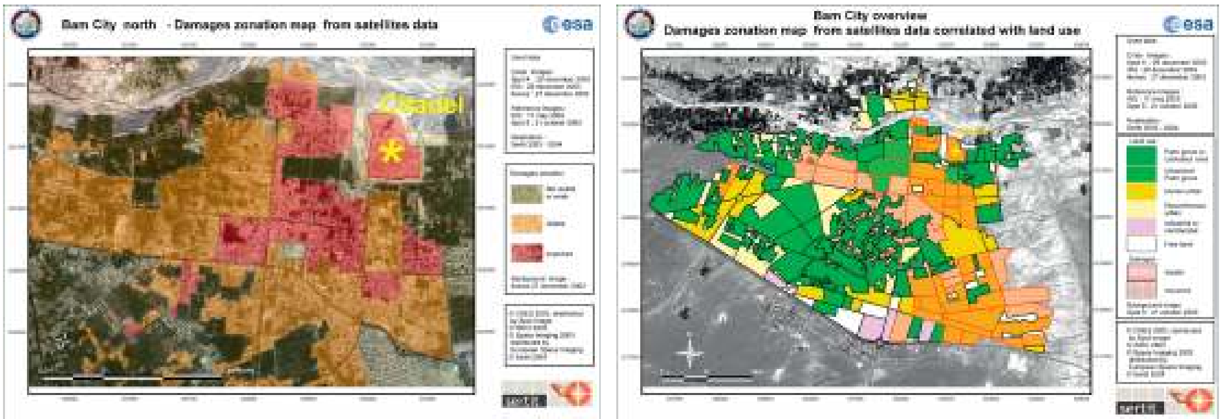

Figure 2. BAM (Iran) Earthquake Damage Zonation provided by Charter.

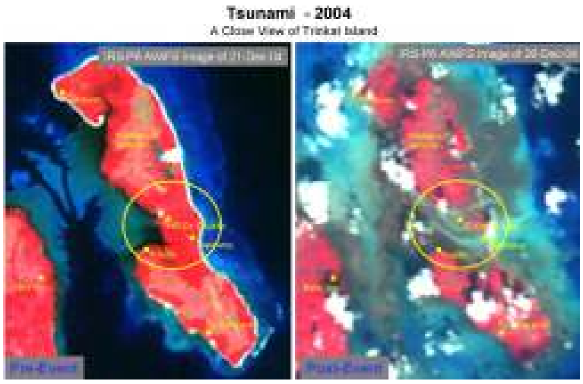

Figure 3. Tsunami Damage Zonation (Anadman & Nicobar Island, India) provided by Charter 21/12/2004–26/12/2004, before and after tsunami provided by IRS satellites.

coastal regions of India, Sri Lanka, Thailand, Indonesia, Maldives, Malaysia, and Myanmar were all severely affected. Bangladesh, the Seychelles, Somalia, Kenya, and Tanzania also suffered damage and loss of life. The charter was activated by ISRO on the same day. ISRO provided the first satellite images from IRS system giving assessment of the damage and areas affected by the tsunami waves (Figure 3). Later using the imageries received from all Charter agency satellites were analyzed and a complete report was provided on damage assessment. The satellite images were very useful for rescuing the people and providing relief material to the affected areas during relief and rescue operations under taken by the respective govt. and NGOs.

Katrina Hurricane: Levees were breached and floodwaters submerged the city of New Orleans after Hurricane Katrina made landfall just south of the city on 29 August 2005. 80% of the city was under six meters of water on 31 August 2005. Along the Gulf coast and the Mississippi, flooding was extensive. Authorities put the estimated death toll possibly in the thousands, as rescue efforts were underway on 31 August. Charter provided very

Figure 4. New Orleans, Spot satellite image.

useful satellite images during relief and rescue operations (Figure 4).

Earth Quake in J&K (India): An earthquake of magnitude 7.6 struck western India at 03:50:38 UTC (8:50:38 local time) on 9th October 2005. The epicenter was located on the India–Pakistan border in the Kashmir region, about 95 kilometres to the northeast of Islamabad. Shocks were felt over a radius of some 300–400 kilometers, in northwest India, northern Pakistan, and Afghanistan. Indian authorities estimate some 1200 dead in the regions of Jammu, Baramulla, Kupwara, Srinagar, Poonch, and Udhampur. ISRO activated the Charter and provided satellite images giving areas affected by the earthquake (Figure 5).

Floods in Bihar (India) — August 2007: The worst floods in 30 years hit Uttar Pradesh and Bihar as unusually intense rains in Nepal persisted,

Jammu and Kashmir prov., Uri Resourcesat-1 LISS-IV
Post-quake, Source: Resourcesat-1, Acquired: 09/10/2005

Jammu and Kashmir prov., Uri Resourcesat-1 LISS-IV
Pre-quake, Source: Resourcesat-1, Acquired: 14/05/2005.

Figure 5. Jammu & Kashmir Earthquake Damage Zonation provided by Charter.

swelling rivers coming out of the Himalayas and causing extensive damage to dams and infrastructure. Estimates are of 200 dead and 12 million people affected. Figure 6 shows the flood-affected areas.

4.1 Recent activations

Earthquake in Pakistan: Wednesday, January 19, 2011 4:30 PM In Dalbandin, several people were injured when the roofs of their houses collapsed, provincial Transport Minister Amanullah Notizai told Reuters, but so far there were no reports of fatalities in the quake, which hit at 1:23 AM (2023 GMT on Tuesday). As dawn breaks and officials reach the affected area, more damage and fatalities may be revealed in an area where traditional simple structures may have fared badly under the strains of the powerful tremor. UNOSAT called by UNICEF operations centre in New York to trigger Space Charter.

Flooding in Brazil: Saturday, January 15, 2011 4:20 AM Brazil, Rio de Janeiro, has been hit by severe floods in 44 years. Brazilian officials have confirmed that more than 500 lives have been lost in the floods. Rescuers had to reach affected areas on foot because vehicles cannot cross blocked roads. Charter was activated to provide data on these floods.

Flood in Australia: Monday, January 03, 2011 4:30 PM Towns across Queensland in Australia's northeast have been evacuated as flooding spreads over an area the size of France and Germany combined with further heavy rainfall forecast. The disaster is of 'biblical proportions'. Flood alerts are in place for at least 10 rivers in Queensland after some regions recorded record rainfall during December, according to the Bureau of Meteorology. Charter was activated to provide data on these floods.

Flood in Panama: Thursday, December 09, 2010 4:30 PM Disastrous flooding and landslides in Panama caused by rains that have continued unabated for the past few weeks (caused by the same phenomenon which has caused devastating flooding and landslides in neighboring Colombia and Venezuela). The country is on 'red-alert' and the flooding and landslides has caused suspension of operations of the Panama Canal, a first in the Canals 95-year history. Charter was activated to provide data on these floods.

Floods in Colombia: Monday, December 06, 2010 6:30 PM Days of torrential rain have brought widespread flooding to Colombia, destroying thousands of homes, killing at least 20 people and about 150 people missing. A state of emergency has been declared in Santa Lucia and Bello. Charter was activated to provide data on these floods.

Forest Fire in Israel: Friday, December 03, 2010 3:30 AM About 40 people have died in what is thought to be Israel's largest ever forest fire, police have said. Many of the victims were prison guards travelling on a bus, which was caught in the inferno in the Carmel Mountains near the northern city of Haifa. Thousands of people, including prison inmates, have been evacuated from the area. Scores more have been injured, the ambulance service said. The cause of the blaze was not immediately known. Israel's Prime Minister Benjamin Netanyahu, who has visited the affected area, said it was an 'unprecedented disaster'. For this charter activated and value adding support has been provided by the European project GMES SAFER.

5 Cooperation with other frameworks

International cooperation has been recognized as one of the important strategies towards providing the access of EO products to the civil defense/disaster man-

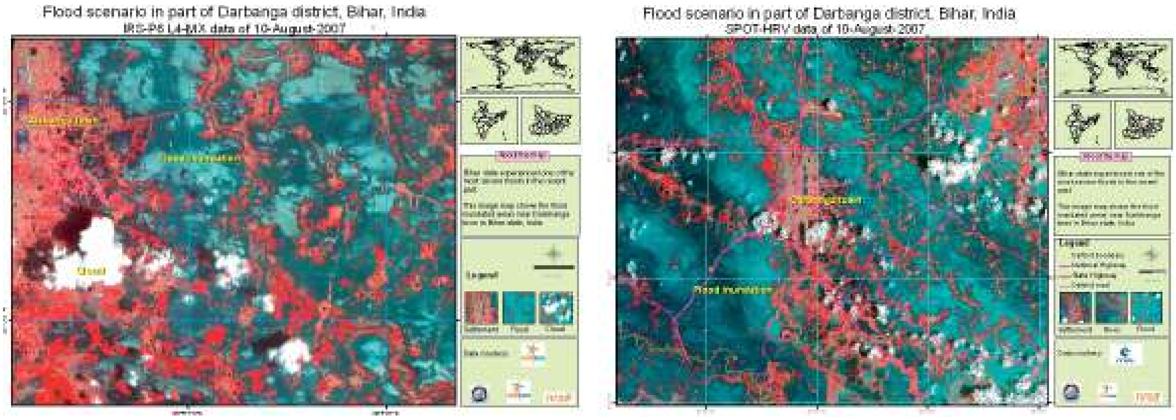

Figure 6. Bihar Floods — Affected Areas provided by Charter.

agement agencies in support of the emergency management. International Charter 'Space and Major Disasters' is a major step in this direction. The main features include an operational mechanism, which delivers EO products to civil protection agencies, emergency & rescue services and to signatories during emergency situations. United Nations is a cooperating body since July 01, 2003 and therefore UN agencies such as UNOSAT can request activations of the Charter through UNOOSA as nodal agency (ESA 2004). Towards a Global Earth Observing System of Systems (GEOSS), the GEO initiative is an important step in putting in place a global system of systems for improved coordination of observations (space & *in-situ*). In GEOSS (CEOS 2005, 2006) framework, Intergovernmental Group on Earth Observations (GEO) has already been set up with a secretariat for monitoring 10-year implementation plan. The central focus has been on observing and understanding the Earth system more comprehensively to expand worldwide capacity to achieve sustainable development with enhanced socio–economic benefits. Reducing loss of life and property from natural and human-induced disasters has been one of core areas of GEOSS (CEOS 2006).

Global Monitoring for Environment and Security (GMES), jointly led by the European Commission and ESA (2004), has been established as a European capacity to produce & disseminate timely and reliable information in support to policy sectors concerning Environment and Security. GMES focuses on providing large-scale operational end-to-end services primarily looking at EU policy sectors. GMES services are relevant to humanitarian aid and disaster risk reduction. There are initiatives by commercial agencies as well. A private company — SERTIT Service for example, which operates through ESA and CNES, has been providing value added products in support of International Charter. It is a good example of public–private partnership. Sentinel–Asia is another 'voluntary and best-efforts-basis initiative' led by the APRSAF (Asia–Pacific Regional Space Agency Forum) to share disaster information in the Asia–Pacific region on the Digital Asia (Web-GIS) platform and to make the best use of earth observation satellites data for disaster management in the Asia–Pacific region. The frameworks, as discussed above, helped in promoting EO products towards disaster reduction in the framework of cooperation. However, most of EO products have been used during the response phase without the participation of stakeholders and also capacity building at the users end. In pre- and post-disaster phase, combining EO products with socio-economic and other *in situ* data adds substantial knowledge and provide structured solutions to the demands at International, national and local level user's. Thus, there is a need to have an arrangement that inspires the participation of stakeholders, enables capacity building and establishes stronger linkages to the end users.

6 Conclusion

The International Charter on Space and Major Disasters is a model of International cooperation and facilitates efficient exchange of EO products. The Charter is operational for more than ten years now, and has been used by the civil protection authorities around the globe for effective disaster management. ISRO as a Partner Agency is playing a key role in the International Charter Operations.

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Disaster, risk and vulnerability due to earthquakes and designing of seismic resistant structure for mitigation

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ABSTRACT

The natural disasters due to earthquakes are not rare or unusual phenomenon in India. This paper examines the cause of earthquake, which accounts for more loss of life and property than any other natural phenomena. It analyses the hazard vulnerability in respect of earthquakes and discusses the usefulness of the Vulnerability Atlas, which is being developed by different organizations in India, for formulating proactive policies to face the threat due to natural hazards. It discusses the different aspects of natural disasters and gives a brief account of the statistics on disasters. Almost 85% of the country is vulnerable to disasters and 54% of the area lies in a high seismic zones and the number of people affected about 90%. This paper discusses the advances in designing seismic resistant structures and performance studies of progressive collapse of structures damage assessment to combat earthquakes and hazard vulnerability in India. It focuses on the fact that increasing urbanization and degradation of the natural environment on a global scale are having the effect in increasing the frequency and severity of disasters around the world. It discusses the statistics of disasters, prevention potential of disaster by societies and appropriate disaster prevention standards. It suggests for the designing seismic resistant buildings and structures for disaster mitigation and management, and it should be a part of sanctioning building plan to meet the challenges of sustainable development.

1 Introduction

Increasing urbanization and degradation of the natural environment on a global scale are having the effect of increasing the frequency and severity of disasters around the world (Ghose, 2005a). With the problem centering on developing countries, India suffers most from these disasters. In the ongoing century, it is certain that disaster will become a major concern in India. Earthquakes account for more loss of life and property than any other natural phenomena. In spite of this fact, and the fact that we know why and how earthquakes occur, there is a great deal of pessimism from both the scientific community and Government agencies concerning one's ability to accurately predict earthquakes. This pessimism is evidenced by the large amount of funds expended in earthquake preparedness programs compared to the funds available for research concerning earthquake prediction. The primary reason for the lack of an earthquake prediction model is the inability of low frequency surface mounted seismic instrumentation to detect the higher frequencies associated with small fractures that occur prior to a large movement of a fault. The high frequencies associated with these small events are attenuated by the upper mantel and never make it to the surface.

Earthquakes, which often cause great destruction and loss of life, volcanic eruptions, which sometimes throw enough material into the atmosphere to cause temporary changes in climate, serve as reminders that the earth is a dynamic, living body that continues to change (Ghose 2005b, Condie 1997). Earthquakes usually arise from plate tectonic processes and originate along the plate boundaries occurring as motion of ground resulting from the release of energy that accompanies in abrupt slippage of rock formations subjected to stress along a fault (Plafaker 1973).

The loss of life and destruction of property by earthquakes makes them some of natures more natural phenomena (Manhan 1999). Distance from the epicenter, the nature of identifying strata, and the types of structures affected may all result variations in intensity from the same earthquake (Lomitz 1970). Earthquakes may cause catastrophic secondary effects, especially large, destructive ocean waves that are called tsunamis Another devastating phenomenon consists of tsunamis, large ocean waves resulting from earthquake-induced movement of ocean floor (Dudley and Min 1998). Tsunamis sweeping onshore at speeds up to 1000 km/hr have destroyed many homes and taken lives, often large distances from the from the epicenter of the earthquake, itself (Satake *et al.*1995). Although many people call tsunamis as tidal waves, but they are not related to tides and they are rather a series of waves, or wave trains, usually caused by earthquakes. Tsunamis have also been caused by the eruption of some coastal and island volcanoes, submarine landslides, and oceanic impacts of large meteorites. Tsunami waves can become more than 30 feet high as they come into shore and can rush miles inland across low-lying areas. The 1960 Chile earthquake ruptured a fault zone along which a slab of sea floor is descending, or sub ducting, beneath the adjacent South American Continent. Such subduction zones are formed where two of the tectonic plates that makes up the Earths outer shell meet. Earthquakes occur when the fault ruptures, suddenly releasing built-up energy. During the 1960 Chile earthquake, the western margin of the South American Plate lurched as much as 60 feet relative to the sub ducting Nazca Plate, in an area 600 miles long and more than 100 miles wide. Some areas around the margin of the Pacific Ocean are located near subduction zones similar to the one that produced the 1960 Chile earthquake and its tsunami. One of these areas is Cascadia-southern British Columbia, Washington, Oregon, and northern California. The tsunami was a result of the largest earthquake ever measured (magnitude 9.5). This quake occurred along the coast of Chile on May 22, 1960.

The objective of this paper is to provide guidelines for analysis of the current situation in India with respect to disaster, risk and vulnerability due to earthquakes and for designing of seismic resistant structure for mitigation with standardization of disaster prevention measures as the context. Also, a role is proposed for India in the effort to develop such standards.

2 Rising population and urbanization

Disaster is defined to mean an uncontrollable natural hazard, or more technically a physical phenomenon, that results in damage. Taking an avalanche in the Himalayas as an example, it would not be considered a disaster unless it resulted in actual damage to human life or property. A disaster, in other words, has an impact on human society. India is geologically characterized by the Pan-Pacific Earthquake Belt and the Himalayan Earthquake Belt, with other volcanic zones overlapping these major areas. Meteorologically, India features frequent typhoons and cyclones in the tropical zone. While temperate low pressure regions that develop in the Himalayas grow as they move eastward, bringing torrential rain along their path. It is apparent that most types of natural force that can cause disaster are present in India. What is worse is that the countries badly affected by such natural forces have over-populated capitals and sprawling urban areas. Population-wise, Asia accounted for about 61% of the world population, about 3.5 billion people, in 1995. And this is expected to grow by 1.4 times to some 4.8 billion by 2025. The population density in 1995 was 109 per square kilometer, 2.6 times the world average, The urban population of Asia accounted for 35% of the total in 1995, and this also is expected to reach 52% by 2025,

Evidence of the accelerating concentration of population in the cities with all its resultant problems. Over 80% of Asian population growth in the 1990s took place in urban areas. The number of cities exemplifies this with a population of over 1 million; there were just 28 such cities in 1950. But this rose to 136 in 1995 and is expected to skyrocket to 243 in 2015 It is essential in any discussion of the likely characteristics of disaster in the 21st century to keep these figures in mind And to recognize the growing risk of enormous disaster hitting the growing urban areas. Let me expand on the specific types of disaster that are common in Asia. In compiling population, social conditions, and data on past events were taken into account in making a comprehensive evaluation. It suggests that the most vulnerable regions are the Philippines, Indonesia, India, China, Bangladesh, and Japan in order of decreasing risk. These countries are characterized by large populations of over 100 million, except in the case of the Philippines where it is somewhat less than 70 million. Damage is maximized in the Philippines because of the wide range of natural forces at work there. Two types of disaster are particularly likely to cause very serious damage: flood and earthquake. Given the frequency with which wind and flood disasters occur, they far outnumber other types in damage severity.

3 Statistics on disasters

Asia have accounted for about 50% of the world total, while other disasters make up about 40% of the total. The most dreadful record is the ratio of Asia's disaster death toll to that of the world as a whole; it is over 90%

for disasters in the 1990s.The figures vary widely over the decades, a result that can be attributed to a few particularly terrible disasters. Such as the 1976 Tangshan Earthquake in China, which killed about 250 000, and a series of severe cyclones that hit Bangladesh in 1970 with a death toll of about 500 000. The death toll resulting from wind and flood disasters jumped by an order of magnitude in the 1990s. But this sudden increase affected Asia's ratio to the world total by about 15 percentage points because there was a worldwide surge in this type of disaster. Clearly, there is an extreme concentration of victims of such disasters in Asia, Another substantial increase is clear in the value of damage caused by typhoons and cyclones; it is now running at 10 times the level of the 1980s. Again, however, the ratio has remained almost unchanged, at about 40%, because hurricanes in Central and North America account for more than 50% of the world total (51.2%, 58.5%, and 54.4% in the 1970s, 1980s, and 1990s, respectively).

It is sadly worth noting that there has been conspicuous growth in the absolute value of damage in both Asia and the Americas. The conclusions we draw from the above results are corroborated by other statistics. Take for example the number of cases where material assistance and international emergency relief activities have been provided to disaster areas around the world by the Japan International Cooperation Agency (JICA). There were 187 such occurrences between October 1987 and September 1998, of which 41 were for wind and flood disasters in Asia and 11 for earthquake or tsunami disasters in Asia. The ratio of assistance to Asia for all types of natural disaster, including volcanic eruption and landslide. This indicates that disasters in Asia account for almost 40% of the world total, while the death toll in Asia is over 40% and the number of people affected is slightly less than 90%. The latter figure is about 2.2 times the ratio of number of occurrences in Asia. To summarize the discussion so far, wind and flood disasters in Asia far outnumber any other type of disaster in frequency, death toll, people affected, and value of damage. According to data accumulated over the past 25 years, natural disasters in Asia account for about 40% of the world total, While the death toll ratio is about 50% and the number of people affected about 90%, meaning that damage to human life is more prominent than other types of damage.

The large tsunami, which struck 11 of the nations, was a complete surprise for the people leaving there, but not for the scientists who are aware of the tectonic interactions in the region. Many seismic networks recorded the massive earthquake, but there was no tide gauges or other wave sensors to provide confirmation as to whether a tsunami had been generated. There was no established communication network or organisational infrastructure to pass a warning of any of any kind to the people coastlines. No tsunami warning system exist in the Indian Ocean as there is for Pacific. The Pacific Tsunami Warning Centre in Honolulu had no way of providing warning information to the region. Part of the problem is that most of the countries in the region have underestimated their potential tsunami threat from the Northern end of the Sunda Trench. Review of the historical records would have revealed that that a very destructive Tsunami occurred in 1941, in the same general area. That particular tsunami killed more than 5000 people in the eastern coast of India,, but it was mistaken as a short surge. Thousands must have gotten killed elsewhere in the islands of the Bay of Bengal in 1941, but there has been no sufficient documentation (Shefard *et al.*1950). Unfortunately, the Regional Tsunami Warning System, Preparedness Program, or effective Communication Plan exists in for this part of the world.

Most of the stress and energy that had accumulated in the Sunda trench were released by the crustal movement that caused the earthquake that generated the tsunami of Dec 2004. The subduction of the India tectonic plate underneath the Burma plate caused upward trusting of an extensive block and generated the destructive tsunami. It is unlikely that another major earthquake will occur in the region in the near future, but stress will start building up again. Although the danger of another major tsunami has passed, a strong after shock in the region could possibly generate a small local tsunami in the immediate area affected by the earthquake. Aftershocks can be expected to last for many days and even weeks and months in the region, but they should diminish in strength with the passage of material that was moved during the major earthquake. The aftershocks represent natures way of restoring stability and temporary equilibrium. Although it is unlikely tat a destructive tsunami will occur again soon in the same region, caution is advised for the coastal residents in Northern Sumatra and in the Andaman and Nicobar islands. If the aftershock is strong enough and it is strongly felt, evacuation to higher elevation is advised. In fact, strong shaking of the ground is natures warning that tsunami may be imminent.

4 Disaster prevention potential of societies

The developing countries like India in common with those in the rest of the world, suffer from the three-pronged threat of decelerating economic growth, environmental degradation, and population growth (Ghose and Ghose 2006). Overall degradation of the global environment has caused a collapse of both natural and semi-natural ecosystems, resulting in increased numbers of natural disasters. Further, rapid urbanization and the concentration of population in cities has had the effect of magnifying the severity of those natural disasters that affect urban areas. It is clearly apparent that a vicious cycle exists in the relationship between disasters in developing countries and poverty there First, provincial areas with a population consisting mostly of farmers experience recurring natural disasters as a result of population growth according to the following process:

(1) The area of productive land per head of population can only fall as population increases; as a consequence, the population moves onto unsuitable and vulnerable land, in many increasing the frequency and severity of disasters.

(2) Farmers settling on land unsuitable for crops suffer damage from disasters, further deepening their poverty.

Stricken farmers either go to town for work or become tenant farmers, thus finding themselves trapped in deep poverty. On the other hand, large cities (including capital cities) also suffer from population inflow and experience disasters with increasing frequency and severity as follows:

(i) Chronic delays in the provision of social infrastructure force 30% to 60% of people to live in closely confined, overly populated areas such as slums.

(ii) Sprawling residential development encroaches into disaster-prone areas.

(iii) The mixing of residential and manufacturing functions, and concentrations of dangerous materials in cities, increases the likelihood of secondary disaster.

Disaster prevention can in a technical sense be categorized into two types of approach: soft countermeasure and hard countermeasure. Satisfactory implementation of both approaches to disaster prevention depends on the availability of money and information. In other words, a country needs to be richer to be resistant to disaster. It is revealed that average life expectancy is one appropriate and general index of degree of affluence. The United Nations then defined the human development index (HDI) as a standard measure of the standard of living in a country. The HDI takes into account gross domestic product, average life expectancy, and educational attainment. And the closer its value is to the higher the standard of living. Countries are ranked into three categories depending on the value of this index: the top is for HDIs of 0.8 or more, the mid for HDIs from 0.5 to 0.799, and the low for those less than 0.5. Population growth greater than 2%, while GNP per capita is as low as 300 dollars or less and the average life expectancy less than 60 years.

5 Appropriate disaster prevention standards

The 21st century is expected to be a period in which cities are the most prominent social feature. One of the implications of this is the certainty that major disasters will affect cities. With approximately 50 countries in Asia, there is considerable danger in discussing a single form of disaster prevention for all of them, since their capacity to handle disasters varies greatly. What, then, should we do about standards for these countries? Countries with lower HDI values are either too budget-restricted to make direct investments in disaster prevention or, even in cases where funds are available, their investments are far less effective than expected. As a result, the disaster death toll does not fall despite their efforts. One possible solution to this would be indirect investment, whereby a disaster prevention strategy is incorporated into the regular public works function. On the other hand, for countries ranked in the mid or upper categories, direct investment in disaster prevention is more effective, Although one may question whether such investment is as competitive cost-wise as in other types of project. The answer is certainly yes if the social value of a person's life is fully quantified, and this is clearly the tendency today When this concept was applied after the HanshinAwaji Earthquake, the social value put on the life of a Japanese citizen was calculated to be about 250 million yen. On this basis, 250 billion yen invested in disaster prevention efforts to prevent the death of 1000 people is justifiable. Naturally, the application of this concept will result in a great gap between the value of a person in a developing country and in an advanced country, since it depends on prices, gross domestic product, and other factors unique to each country.

6 Design of seismic resistant building and structures

Earthquakes have varied effects, including changes in geologic features, damage to man-made structures and impact on human and animal life (Ghose and Ghose 2007).

Earthquake Damage depends on many factors:

- The size of the Earthquake.
- The distance from the focus of the earthquake.
- The properties of the materials at the site.
- The nature of the structures in the area.

Frequency of shaking differs for different seismic waves. High frequency body waves shake low buildings more. Low frequency surface waves shake high buildings more. Intensity of shaking also depends on type of subsurface material. Unconsolidated materials amplify shaking more than rocks do. Buildings respond differently to shaking depending on construction styles, materials Wood — more flexible, holds up well. Earthen materials, unreinforced concrete — very vulnerable to shaking. Buildings that are not designed for earthquake loads suffer more

- Geomorphological changes are often caused by an earthquake: e.g., movements — either vertical or horizontal — along geological fault traces; the raising, lowering, and tilting of the ground surface with related effects on the flow of groundwater;
- An earthquake produces a permanent displacement across the fault.
- Once a fault has been produced, it is a weakness within the rock, and is the likely location for future earthquakes.
- After many earthquakes, the total displacement on a large fault may build up to many kilometers, and the length of the fault may propagate for hundreds of kilometers.

6.1 Earthquake risk

Consists of 3 components: Hazard, Vulnerability and Exposure: 60% Indias land area under Moderate-to-Severe Seismic Hazard Vulnerability

Building Stock in India

❄ RC ∼ 65 40 000

❄ Ordinary Brick ∼ 4 91 76 000

❄ Adobe and Rural ∼ 13 97 12 000

❄ Informal ∼ 5 36 72 000

Total 24 91 00 000

❄ Very few Professionals in India with knowledge of Design for Earthquake Effects.

6.2 Elements of a community at risk

- Housing
  - Single Storey
  - Multi-storey
    - High population density
- Infrastructure
  - Public buildings
  - Health facilities
  - Systems
    - Communication
    - Transportation
    - Water supply and sewage
    - Electrical power
    - Gas and Petroleum
  - Fire services
  - Commercial centers
  - Industrial facilities

6.3 Paradigm shift is necessary

Reduce Risk or React to Disasters

- Revision of codes and standards
  - Regular revisions of Existing Standards
  - Development of New standards
    - Incorporate latest knowledge
- Development of Techno-Legal Regime
  - Town and Country Planning Acts
  - Land Use and Zoning Regulations
  - Development Control Regulations
  - Building Bye-laws
- Techno-Financial Regime
  - Financial Institutions
  - Financial Transactions
    - To be made contingent on compliance
- Earthquake resistance in existing structures
  - Selective retrofitting of critical & lifeline structures ONLY
    - Types of structures identified
    - Cities/towns prioritized

6.4 Disaster triggers

- Institutional reaction and response management
  - Based on scale of earthquake disaster
  - Four levels recommended
    - Level 0: Non-Disaster Situation
      - Focus on Mitigation and Preparedness
    - Level 1: Minor and Localised Incidents
      - Handled at the local level
    - Level 2: Disasters
      - Handled at the state level
    - Level 3: Major Disasters
      - Beyond the capacity of the state government

6.5 Implementation plan

Six focus areas

(1) Awareness and Preparedness

(2) Response

(3) Education, Training, Capacity-Building, Research & Development, and Documentation

(4) Regulation and Enforcement

(5) Earthquake-Resistant Construction of New Structures

(6) Selective Seismic Retrofitting of Existing Critical and Lifeline Structures

6.6 Action plan in each focus area

- Shall be developed by concerned ministry/department/body at central, state and local levels
- Shall be approved by NDMA
  - Ensure that no gaps are left
- Shall confirm to NDMPAG-EQ
  - Be developed using a consultative approach

The lesson to be learnt from the recent disasters, of course, is that such a system must be up in place as early as possible. It has been stated that India will have its own system. However a coordinated approach to device a system, among the affected countries and even the other countries, which did not suffer on this occasion, is needed so that the respective Governments can react quickly to safeguard the interests of the populations (Ghose 2005c). An early warning system must also be backed up by a detailed and well thought out Digester management plan. Engineers should be developed with all the major special skills required: planning, cost calculation, design, and construction. These engineers should then be dispatched and backed up by a suitable support system for them. Civil engineers should be developed who can manage local contractors, develop easy-to understand methods that facilitate a transfer of quality control and construction management concepts, and prepare alternative plans for different balances of mechanical operations and labor. Construction experience gained in various locations should be data based to allow contractors in the same line of business to share and make joint use of the information.

7 Conclusion

There is an increasing urbanization and degradation of the natural environment on a global scale. They are having the effect of increasing the frequency and severity of disasters around the world. With the problem centering on developing countries India suffers most from these disasters. In this ongoing century, it is certain that disaster will become a major concern The importance of forecasting, satellite and remote sensing, computerized systems of vulnerability and risk assessment and other technologies for warning and monitoring cannot be ignored. It is suggested that seismic resistant buildings and structures must be a part of sanctioning building plan. The developing countries, though they do have civil engineering researchers, generally have no civil engineering academic association that pulls them all together. This creates an environment where, in a public work project, technical issues fall by the wayside and politicians and bureaucrats make the decisions. This discussion may have provided guidelines for analysis of the current situation in India with respect to disaster management. It suggests for the designing seismic resistant buildings and structures for disaster mitigation and management, and it should be a part of sanctioning building plan to meet the challenges of sustainable development.

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Emergency planning in a hazardous chemical facility — A tool for effective disaster management

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ABSTRACT

India is spearheading towards a rapid expansion of Hazardous Chemical Facilities. The safety in these facilities is of prime concern. The consequences due to release of chemicals from the facility into the public domain attracts attention of media and may cause panic to public. The paper focuses on hazardous chemical processing facility under Department of Atomic Energy (DAE) involved in manufacture of heavy water by hydrogen sulfide (H_2S) gas–water exchange process. The emergency planning process in case of advertent H_2S release involves, zoning (exclusion zone and sterilization zone) around the plant, probable release scenarios, modes of declaration and termination of emergency, actions of facility/local authorities, emergency resources, etc. The preparedness for emergencies is ensured through periodic emergency exercises and mock drills involving facility and local administration officials. Atomic Energy Regulatory Board (AERB) as a regulator oversees the effectiveness and efficacy of the emergency plans and preparedness in Hazardous Chemical Facilities of Department of Atomic Energy (DAE).

1 Introduction

A developing country like India is moving towards a rapid expansion of hazardous chemical industries be it, petrochemical, fertilizer, heavy chemicals, pesticides, pharmaceuticals, etc, which involves handling, storage, transportation and processing of hazardous chemicals. The safety in these facilities is of prime concern. The consequences due to release/discharge of chemicals in any form (liquid, vapor, gas, smoke, dust or any combination of these) from the facility into the public domain attracts attention of media and may cause panic to public. The Bhopal accident has changed the attitude of the government, plant managements and the administrative machinery from relief, rescue restoration and rehabilitation approach to prognostication, prevention, planning and preparedness with respect to hazardous facilities.

2 Statutory & regulatory provisions on emergency planning

The legislations relevant to Hazardous Chemical Facilities which contain exclusive provisions for On-site and Off-site emergency planning passed in the parliament are mentioned below:

2.1 Statutory provisions

Manufacture, Storage and Import of Hazardous Chemical (MSIHC) rules, 1989:

These rules are laid down under the Environment (Protection) Act, 1986. The preparation of On-Site/Off-Site Emergency plans is necessary based on storage of hazardous chemicals exceeding threshold quantities which vary with the nature of the chemical.

Rule 13: Preparation to On-site emergency plan by the occupier:

An occupier shall prepare and keep up-to-date an On-site emergency plan of how major accidents will be dealt at the site on which the industrial activity is carried on and that plan shall include the name of the person who is responsible for safety on the site and the names of those who are authorized to take action in accordance with the plan in case of an emergency. The occupier shall ensure that a mock drill of the on-site emergency plan is conducted every six months.

Rule 14: Preparation of Off-site emergency plan by the Authority:

It shall be the duty of the concerned authority to assist the district authorities in the preparation of Off-site emergency plan of how emergencies relating to a possible major accident on that site will be dealt with and in preparing that plan the concerned authority shall consult the occupier and such other persons as it may deem necessary. The concerned authority shall ensure that a rehearsal of the off-site emergency plan is conducted at least once in a calendar year.

2.2 The chemical accidents (Emergency planning, preparedness, and response) Rules, 1996

These rules are framed to tackle/mitigate the emergencies due to chemical accidents. These rules describe about the constitution of the Crisis groups at Central, State, District and Local levels and the functions for each level are laid down in the following rules.

Rule 3: Constitution of Central Crisis Group

Rule 6: Constitution of State Crisis Group

Rule 7: Functions of the State Crisis Group

Rule 8: Constitution of the District and Local Crisis Group

Rule 9: Functions of the District Crisis Group

Rule 10: Functions of the Local Crisis Group

Rule 12: Aid and Assistance for the functioning of the District and Local Crisis Groups

1. The Major Accident Hazard installations in the industrial pockets in the district shall aid, assist and facilitate functioning of the District Crisis Group;
2. The Major Accident Hazard installations in the industrial pockets shall also aid, assist and facilitate the functioning of the Local Crisis Group.

Rule 13: Information to the Public.

1. The Central Crisis Groups shall provide information on request regarding chemical accident prevention, preparedness and mitigation in the country;
2. The State Crisis Group shall provide information on request regarding chemical accident prevention, preparedness and mitigation to the public in the State;
3. The Local Crisis Group shall provide information regarding possible chemical accident at a site in the industrial pocket and related-information to the public on request;
4. The Local Crisis Group shall assist the Major Accident Hazard installations in the industrial pocket in taking appropriate steps to inform persons likely to be affected by a chemical accident.

2.3 Regulatory provisions

Under Schedule 5 of MSHIC Rules, AERB is identified as authority with legal backing under the Atomic Energy Act, 1962 for units of Department of Atomic Energy (DAE).

The duties of AERB are:

- Notification of major accidents as per rule 5(1) and 5(2)
- Approval and Notification of Sites as per rule 7;
- Safety report and safety audit reports as per rule 10 to 12;
- Acceptance of On-site Emergency plans as per rule 13;
- Assisting the District Collector in the preparation of Off-Site emergency plans

2.4 Regulatory documents

AERB has been drawing up codes, guides, standards and manuals to facilitate the work of the concerned facilities organisations in implementing the necessary safety regulations AERB has published the following documents related to emergency planning:

AERB safety guidelines no. AERB/SG/EP-3, preparation of site emergency preparedness plans for non-nuclear installations

This document pertains to the drawing up of Emergency Preparedness Plans (EPP), where required, for various installations of the Department of Atomic Energy and gives guidance to the concerned organisations, to enable them to draw up the necessary EPP. The document takes into account the statutory requirements.

AERB safety guidelines no. AERB/SG/EP-4, preparation of off-site emergency preparedness plans for non-nuclear installations

This document outlines the requirements for preparation of Off Site Emergency Preparedness Plans (OSEPP) for a non-nuclear installation, which are required to have an OSEPP under the statutory provisions. The rules specify the nature of information that shall be furnished in OSEPP as well as the essential criteria or issues that need to be addressed in the Plan. The Annexure to this document contains a list of chemicals currently used in DAE units along with threshold quantities, which if exceeded, require the preparation of OSEPP.

AERB safety guide no. AERB/SG/G-5, role of the regulatory body with respect to emergency response and preparedness at nuclear and radiation facilities

The objectives of the safety guide are: The Regulatory Body has the responsibility to check and ensure that the mitigating actions as per approved plans are taken during an emergency.

To achieve this, the following requirements have to be fulfilled:

(i) Establishment of approved emergency preparedness manuals for nuclear and radiation facilities, identification of responsibilities of various organisations and agencies to intervene during emergency;

(ii) Maintenance of adequate state of emergency preparedness at the nuclear and radiation facilities; and

(iii) Revision and updating of existing emergency preparedness manuals periodically reflecting the latest inputs available.

3 Case study: Emergency planning in a H_2S gas-based hazardous facility

The facility under our study is a hazardous chemical processing facility involved in manufacture of heavy water, a prescribed substance used in the production of nuclear power in India. The hazards foreseen in this facility are of chemical nature. The facility is designed with built-in and well engineered safety features to prevent any release from its equipment. The safety requirements for this facility are ensured by strict regulatory controls. The process essentially contains production of a toxic, flammable and corrosive gas namely hydrogen sulfide gas through chemical double decomposition. The hydrogen sulfide gas is utilized for the bi-thermal chemical exchange with natural water and isotopic enrichment to produce reactor grade heavy water. The inventory of the hydrogen sulfide gas in the facility is about 400 tons, mainly confined to the process towers, storage tanks and hold-up in pipelines. The facility stores, handles and processes the hydrogen sulfide gas at various stages of production process.

The safety of the plant, public and the environment is given due consideration right from the siting stage of the facility and it is ensured during the progressive stages till regular operation. The safety features are engineered in the design for the safe remote isolation, dumping and flaring or transferring back to storage tanks from the process towers. The safe operation of the facility is ensured through approved technical specifications for operations. The probable hydrogen sulfide gas release scenarios are identified. The various types of emergencies like Plant emergency (affecting plant areas only), On-site emergency (affecting the entire plant site) and Off-site emergency (affecting the areas in public domain) are envisaged. The emergency plans

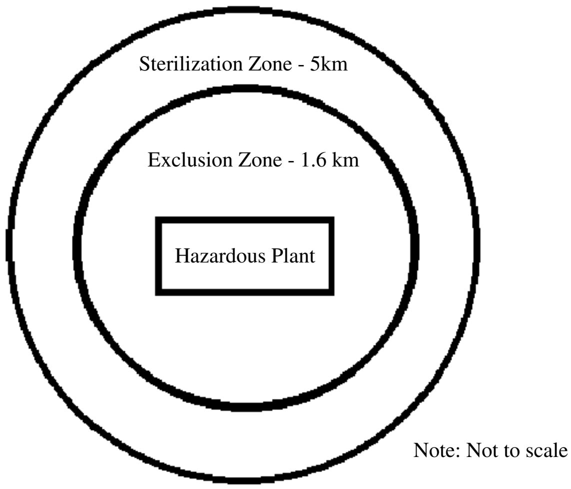

Figure 1. Typical Emergency Planning Zones for Hazardous Chemical Facility.

for mitigating the emergencies cited above are well laid out.

The emergency planning process involves, zoning around the plant — exclusion zone (buffer area of about 1.6 km radius with greenery only)and sterilization zone (population controlled area of about 5 km) shown in Figure 1.

Adequate number of hydrogen sulfide gas detectors (of suitable range) strategically located around the plant areas and the off-site areas in the public domain are available for detecting leaks/gas releases. The criteria for intervention actions like alert, standby and actuation of action plans etc based on gas levels detected in the facility areas and/or in the public domain are laid down. The hydrogen sulfide gas releases are envisaged at two levels i.e ground level (1.5 m from ground) and higher elevation releases (from storage areas, towers & flare stack). The Ground Level Concentration (GLC) dictates the protective measures to be taken. The GLCs are calculated using the software programs available in the literature. The GLCs for worst case ground level scenarios is calculated by using ALOHA (Areal Locations of Hazardous Atmospheres) 5.4.1.2 and for higher elevation worst case scenarios, PHAST (Process Hazard Analysis Software Tool) 6.21 is used (Tables 1 and 2).

From the above GLC values, it can be inferred that the ground level releases have an immediate effect at 1 km distance which is within the plant site. The consequences are controlled as plant as viable emergency plans. If necessary, the emergency actions can be initiated and situations can be mitigated. In case of, the worst release scenario at higher elevation, the area beyond 1.5 km and between 5 km has the presence of hydrogen sulfide gas in such a level (below Permissible Level of Exposure (TWA)-10 ppm specified in the Second Schedule of the Factories Act, 1948) where significant health impact (Immediate Danger to life and Health (IDLH-100 ppm)) is not foreseen. The protective measures to be taken in case of emergency like covering the nose and mouth with wet cloth, moving in the direction opposite or perpendicular to the wind direction, assembling at the designated shelter are initiated, if the situation so demands.

Table 1. Ground Level Concentrations (GLC) in ppm of Hydrogen Sulfide gas at various distances using ALOHA for Stability Class 1.5F.

Release Scenarios—Ground level	1.0 km	1.5 km	3 km	5 km
1.5 Te/hr for 30 min	138	66.6	36.2	12.7
0.5 Te/hr for 30 min	30.8	16	4.7	1.8

Table 2. Ground Level Concentrations (GLC) in ppm of Hydrogen Sulfide gas at various distances using PHAST.

Scenario	Class	1000 m	1500 m	3000 m	5000 m
Dump of tower inventory from flare stack (126M El)	1.5F	–	–	1.3	6.5
	1.5D	135	142	74	42
	5D	–	0.8	6	6.2
1 hole in the tower at 50 m	1.5F	33	26	15.2	9.2
	1.5D	30	19	7.6	3.75
	5D	7	5	2	1

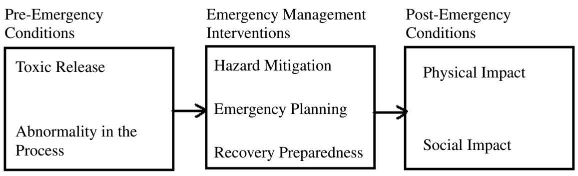

Figure 2. Emergency Impact Management Model.

4 Emergency impact management model

An emergency occurs when pre-emergency conditions are uncontrolled. The extreme event like spread of gas into public domain may exceed a communitys ability to cope with that event. The emergency can be divided into three sections for clear understanding as Pre-Emergency Conditions, Emergency Management Interventions and Post-Emergency Conditions as shown in Figure 2.

Pre-Emergency Conditions: These are conditions which may lead to emergency. Generally before emergency, there will be a toxic gas release or some abnormality in the chemical process. If we can identify the precursors, emergencies can be prevented

Emergency management interventions:

These are actions taken during emergency. Hazard Mitigation, Emergency Planning and Recovery preparedness are the processes. Organisation-structure, hierarchy of emergency response personnel right from Site Emergency Director downwards, their designations and alternative officials are clearly defined in SEPP. Resource Groups having the resources/training to carry out the duties set upon them to cope with an emergency which covering (i) communication, (ii) public announcements code for declaration & termination of emergencies, (iii) monitoring of toxic releases into the environment, (iv) emergency shelters at the Facility, (v) transport for evacuation of plant personnel, (vi) medical care including administration of antidotes, and (vii) security/maintenance of Law and Order.

Post-emergency conditions:

This phase after the emergency is critical. The physical and social impact such as the loss of good will, fear among the public should be addressed

5 Conclusion

The hazardous chemical facility shall have Emergency Preparedness Plans. The preparedness for emergencies is ensured through periodic emergency exercises/mock drills i.e. for on site once in six months involving facility personnel and systems and off-site once in a year involving facility and local administration officials. The observations of the exercises shall be reviewed in the feedback meeting conducted after the exercise and necessary corrective actions shall be taken for improvement.

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Land use planning technique to reduce vulnerability to flood in coastal village: A case study of Kaikhali village in south 24 Parganas, West Bengal, India

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ABSTRACT

Socio-economic vulnerability to disaster is not in isolation with physical vulnerability. Socio-economic conditions largely depend upon how activities are spread over the land i.e. land use. In an urban setting it is largely based on anthropogenic decisions and choices but in a rural setting it is more of the natural characteristics viz. soil, topography, geomorphology, vegetation cover that decides the use of the land viz. agriculture, fishery, plantation, forestry, fishing etc. Hence, to reduce socio economic losses due to flood, it is essential to plan physical distribution of activities concordant to the natural ecosystem (coastal in this study) of an area so as to sustain livelihood even after a natural disaster viz. flood. This paper will focus on land use/land cover conversion, functionally & topographically suitable location for flood shelter and improved transportation network to enhance the economy. This study had been completed using Geographic Information System (GIS) and Remote Sensing (RS) techniques.

1 Introduction

Kaikhali village and island (study area) is situated in the active delta of Sunderban with changing coastal land forms and facing the threat of submergence due to sea level rise along with periodical exposure to the disasters viz. flood, occurring as a result of storm surge. The challenge lies here is that of saving the island from extinction & adopt a mechanism to mitigate disaster as well as provide villagers with stronger economy. A detailed district level vulnerability analysis both social and physical, shows very little scope of resettlement and rehabilitation from the coastal fringes to interior parts of South 24 Parganas (S24Ps). Hence, an in-situ solution for the study area based on its own potential and constraints is a must to be framed.

2 District profile with respect to vulnerability to flood

The Ganga-Brahmaputra deltaic Indian district of S24Ps is primarily agricultural acting as periphery to the commercialized and industrialized center of Kolkata metropolis. The southern part has a littoral ecology with Sunderban spread over 4263 sq. km. Unstable geological condition, low lying flat plain with an elevation of 0 to 11mamsl exposes it more to the risk of submergence (sea level rise by 50 cm by 2050 & 1 m by 2100). Besides, though the frequency of tropical cyclone and storm surge has not increased the intensity of disaster has increased. This may be highly attributed to the increasing number of economically backward people getting settled in the coastal fringes, destruction of man-

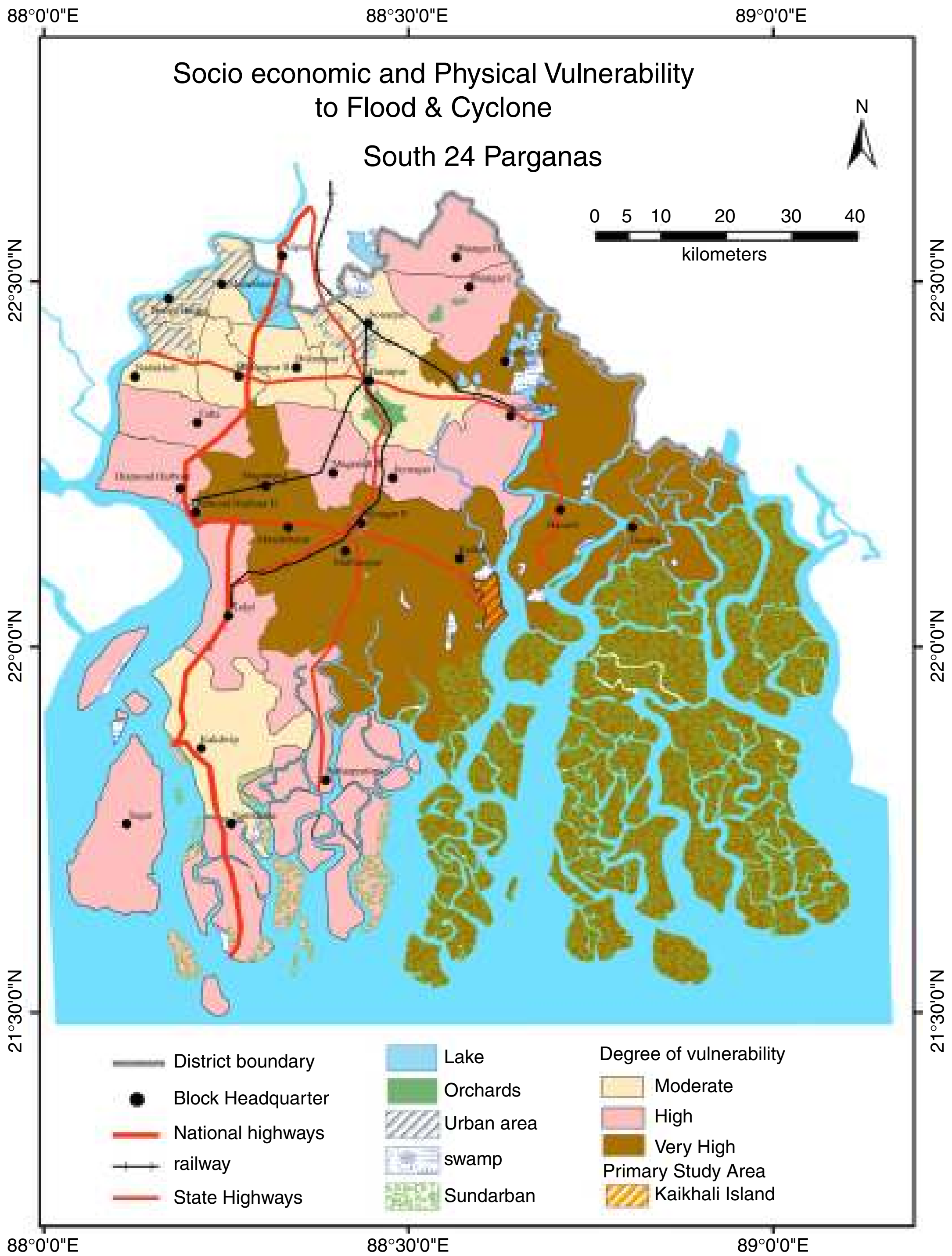

Figure 1. Vulnerability to disaster due to cyclone and flood.

groves for fuel and construction wood or to make way for fishing boats etc. that would have otherwise acted as a buffer to flood and cyclone.

Vulnerability of the district has been worked out based on physical *(elevation of the land, nature and height of the embankment if present, amount of coastal erosion and inundation)* and socio-economic *(Population Density, rural settlement spacing, population in age-group 0-6, Literacy, Agricultural, Industrial and non workers, Agricultural land, Infrastructure, Population to be affected due to sea level rise and vulnerable embankment)* parameters. Cumulative ranking given to socially and physically vulnerable zones clubbed with the degree of exposure to hazard has resulted into the combined vulnerability of the district to flood and cyclone (Figure 1). It has three zones viz. Very high , high and moderate. The degree of vulnerability is very high in Gosaba, Basanti, Canning I & II, Jaynagar II, Kultali, Mathurapur I & II, Magrahat I, Diamond Harbour II and Mandirbazar. Mostly this class is in concordance to the social vulnerability analysis and includes both moderate and severe hazard prone areas. Sagar, Namkhana, Patharpratima, Kulpi, Diamond Harbour I, Falta, Bhangar I & II, Jaynagar I & Magrahat II lies in High Vulnerable zone which mostly lie in 'high social vulnerable' category also. Rest of the blocks lies in moderate vulnerability zone. 31%

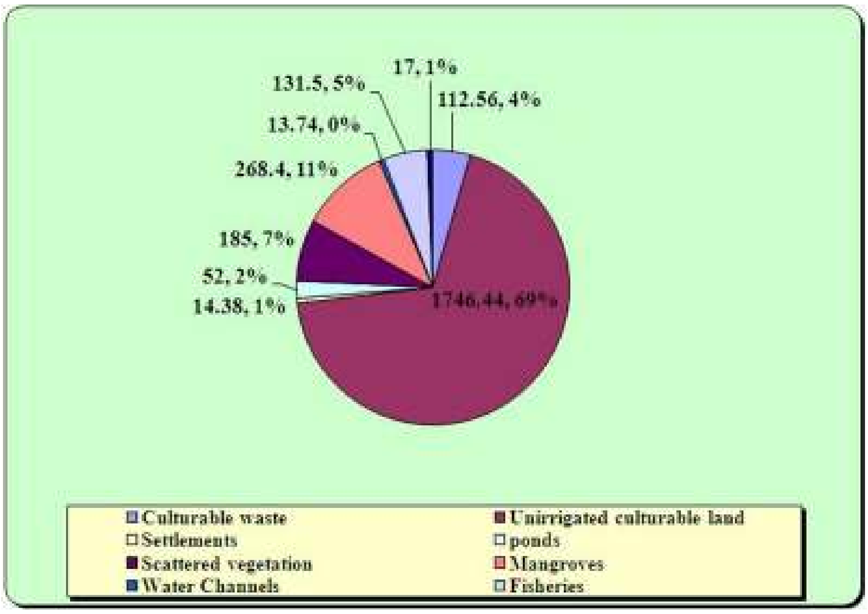

Figure 2. Land Utilization in Kaikhali village (Source: Census, 2001 and map-based calculations).

(1853867) of the population is in 'moderate zone', 35% (2113720) in 'high' and 34% (2002278) in 'very high zone'. The findings show that vulnerability of the district is triggered highly by socio economic factors. And it is the hypothesis of the study that socio economic factors are highly affected by distribution of activities over the land i.e. land use. It is also concluded from the above analysis that resettlement of more than half the districts people is little ambitious a thought and a plan needs to be framed to trigger in-situ socio-economic development that has been attempted in this study through land use planning.

Hence, on one hand, there lies a challenge of structural mitigation on the face of the districts ever changing ecology, geology and climate change scenario and, on other hand, there lies the challenge to strengthen the socio-economic setup by providing alternatives to people who have been predominantly skilled to do farming activities.

3 Island profile with respect to vulnerability to flood

Kaikhali Village Island (Kultali Sub division) the primary survey area falling in the 'very high vulnerable zone' (Figure 1) was inundated and devastated in Cyclone Aila, May 2009. Total area of the island is 22.73 sq. km (2273 ha) while the island along with mangroves makes up 25.41 sq. km (2541.02 ha). Out of which 74% land is under cultivation mostly un-irrigated, 26% of the land is under non cultivation use that includes residential areas, water bodies (ponds, fisheries), roads (paved, unpaved) etc. 4% of culturable waste land includes gauch and groves. Mainly 'bani', 'kewra', 'kolsa' species of mangrove is found here covering 11% of the island bordering it intermittently and in very less density. They are cut for fuel, construction and making way for boats in the event of lack of jetties by the villagers. Break up of land use is as given in Figure 2. It has population of 5180 (Census, 2001) and 912 households with a density of 666 persons/sq. km & illiterates of 55%. They are mostly in-migrants from adjacent districts settled in abadi land. Out of them 66% are categorized as non workers depicting the retarded economic condition of the village.

Elevation of the island ranges from 0 to 10 meters above mean sea level. Contour of 0.5 m interval has been extracted from Shuttle Radar Topography Mission (SRTM) data using Erdas Imagine & Arc GIS (Remote Sensing and GIS software). Based on Triangulated Network Model, area of submergence by 2050 and 2100 have been calculated to be 0.084 sq. km & 0.17 sq. km (0.75% of 22.66 sq. km) with a rise in sea level by 50 cm and 100 cm respectively. So, there is little possibility of the island getting submerged by next century. The extent of non recovered damage & intensity of impact prevalent after seven months (Primary survey conducted) of Aila cyclone clearly depicts its high degree of vulnerability and lack of coping capacity. Worst affected is agriculture and 65% of villagers directly earning livelihood from it, because of saline water inundation that had a Standing height of 2 m for initial two days then it receded to 1.5 m in next three days. Hence soil salinity shooted up from 2 to .6 millimhos/cm (normal range) to 20 to 25 millimhos/cm. It will take at least three monsoon rain to wash away the salt. Salt resistant crop varieties is another option being tested on pilot basis but showing a moderate productivity. Personal interview of farmers so affected reveals their complete loss of livelihood expect for those few getting a job under contractors for embankment construction or as maids for handful of tourists picnicking there (during the period of survey).

Next prominent livelihood is shrimp fisheries occupying 5% of the islands area and directly support-

Figure 3. Mud cut out from the river bank and deposited along the embankment.

ing 11% of villagers, not as owners but as laborers. Shrimp farming requires saline water & for that purpose constructed along the rivers outside the embankment boundaries. They are shallow in depth (0.6 to 0.7 m) and each on an average covers an area of 500 sq. m. After Aila , because of salt water inundation all the fresh water ponds' salinity has shooted up to 30 to 35 millimhos/cm (KVK). In the event of total devastation, it is this option of farming shrimps and other salt water fish species that have been exploited by few and has a potential to be the livelihood of majority. However in the present practice of shrimp farming, hatcheries are located inland and pose a threat of soil and ground water salinisation. The depth to ground water table is quite shallow at places, ranging from <1 m to 430 m. Here the fresh water aquifers are naturally interspaced by saline aquifers. Few shallow tube wells are used for irrigation drawing water from a depth of 45 to 60 m. Generally, drinking water is extracted from 240 m or 335 to 430 m. Dispersed & linear settlement pattern along the embankment, water channels, outer slope of the embankment etc. is attributed to nearness to work place (for fishermen, boatsmen, farmers). This is also a reflection of lack of proper transportation facility and affordability (to buy land or commute daily) to stay inland. Personal interaction with villagers brings forth poor economic condition to be the major reason for choosing vulnerable locations for dwellings.

The village is still not connected with the electric grid and has a pucca road lately constructed by the Ramakrishna Ashram as the only connectivity with the main land apart from navigable water way. Amongst other civic amenities it has a primary school, child and women health care center within 2 kms and rest all beyond 6 to 10 kms. No news paper reaches the island. This makes it vulnerable in terms of warning or information dissemination that happened during Aila. People hardly got time (average 15 minute response time) to save their belongings and knew about the disaster only when flood water started entering their house. Embankments surround almost every part of the island but are of in adequate engineering quality. Normally, the embankments are 3 m high, with top width of 2.5 m, base width of around 12 m and a slope of 30°. They are earthen embankments with brick pitching at places and that to only river side slope. This doesnt seem sufficient enough to protect the island from the furious Matla River which is of a width (3 km) and surges 2 to 2.5 m high (as during Aila cyclone). A matter of serious concern is that local material mud is used in building or repairing the bunds and is excavated from the river banks (Figure 3) which makes it more prone to toe erosion. Moreover, salt content of the mud makes it less cohesive thus making it more prone to breaching. Trees and shrubs also grow on the slopes loosening the embankments.

4 Issues identified and addressed

The key issues identified and addressed with respect to spatial planning are as follows:

- Agriculture, the main occupation is highly vulnerable to saline water inundation as a result of storm surge. Soil gets degraded.
- Shrimp farming has the potential to survive the flood fury more than agriculture.
- Lack of warning dissemination channel, little or no response time and lack of a flood shelter.
- Lack of transportation facility.
- Destruction of mangroves.

5 Mitigation measures

All the above mentioned issues have been addressed through three set of measures of spatial planning viz.

- Land use/land cover change.
- Location of flood shelter.
- Improved transportation.

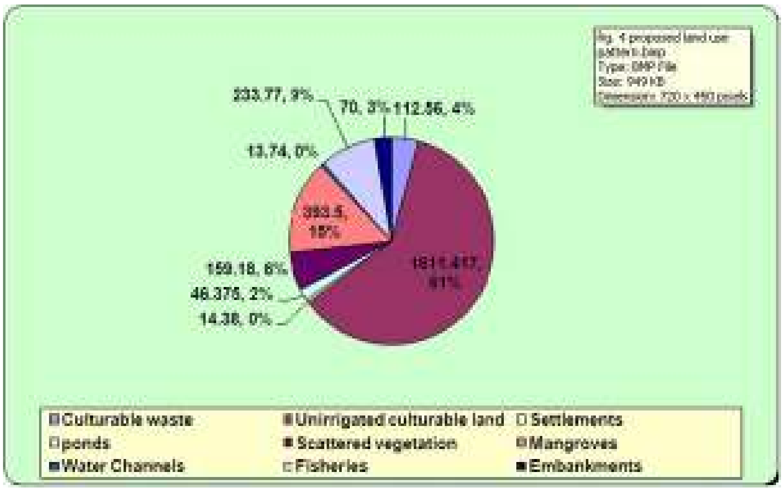

Figure 4. Proposed land use pattern.

Land use/land cover change: The proposal includes mangroves restoration, shifting the embankments landward and intervening space to be used as bherries/shrimp farms. The rationale behind this conversion is to provide:

- ➢ Flood buffer through 'open system' approach i.e. in concordance with the ecosystem.
- ➢ Setback for the embankment i.e. preventing toe erosion.
- ➢ Encouragement for improved traditional system of shrimp farming. Alternative livelihood, not as adversely affected by flood as is agriculture.

The proposed land use pattern (Figure 4) would convert 8% of the agricultural land into embankment and bherries. Land under embankment would increase by 2%, mangroves by 3% and fisheries by 4%.

Restoration of mangroves: This would be done on (Figure 6) on mudflats, upto High Tide Line, in areas from where they have been cut down. Also, remnants, if any, have been taken as the limit while proposing. Total area proposed is 125 ha. Species like bani (8 m) and sundari (10 m) could be planted. Their height would also help in reducing the flood (& cyclone) effect. Natural land formation & siltation will occur as the mangroves will arrest the slit which is otherwise blocked by embankments and also gets prone to toe erosion. Mangroves will encourage natural breeding of prawn seeds (if it does not suffice hatcheries are to be set up but beyond CRZ limit) & also act as soil binders, nitrogen cyclers, pollutant filters. Prawn seed collection and loss of other fries in the process will be discouraged as the prawn seeds could be directly led into the fisheries during high tide. (ratio of number of other fries lost when a single shrimp fry is collected is 1:1611).

Traditional shrimp farming: From HTL to 100 m inland *traditional shrimp farming* has been proposed. Mangroves will serve as natural breeding place for shrimp and they could be let in along with the high tide through small channels and sluice gates. Since traditional and improved traditional farming is allowed in CRZ by The Coastal Aquaculture Authority (formed under Environmental Protection Act 1986, Section 3(3) & administered by the Ministry of agriculture) along with sustainable measures to protect the soil and water environment.. Total proposed area is of 102 ha (100 m $\times$ 14000 m). Mostly brackish aquaculture field area ranges from one to 100 ha. It is 100 m in width from the HTL; also 100 m away from most of the village settlement (Figure 6). Water could be channeled in & out of the fishery through a system of log gates. Each plot should be less than 2 ha. with a depth of 2 to 3 ft (Primary survey & Coastal Aquaculture Authority (CAA) Act, 2005 Guidelines). Clayey loam soil with pH 7-8 and EC >4 mhos/cm is suitable and mostly found in this area. Rest site feasibility study & EIA should be conducted since it is more than 40 ha. (CAA).

A cooperative system will help enhance peoples' income since it will curb the impacts of middlemen and will provide an alternative livelihood to many. Also stronger embankment (discussed above) will prevent breeching and saline water inundation which destroys agricultural land. Channels will not be cut through the embankments to feed the fisheries thus strengthening them even more. Also it will save energy and money since pumping is not needed which is done in some cases. Since it is a conversion of mostly mono cropped land into fisheries and embankments the cost is not expected to exceed the benefits. However, a detailed cost benefit analysis is recommended before conversion. Rest for sustainable management guidelines given by the Coastal Aquaculture Authority has to be followed.

Embankment: Total area proposed for embankment is of 70 ha with base height of 50 m (Figure 6) by the side of the fisheries. With a height of 10 m, slope of 1:1.25 rise by run & topwidth of 6 m (Figure 5) the embankments can also serve as a transportation route (heavy vehicles not permitted). The height of the embankment has been taken as 10 m since sea level rise coupled with high spring tide (range of 5 to 8 m) can result in high storm surge (2.5 m storm surge experienced during Aila, 2009).

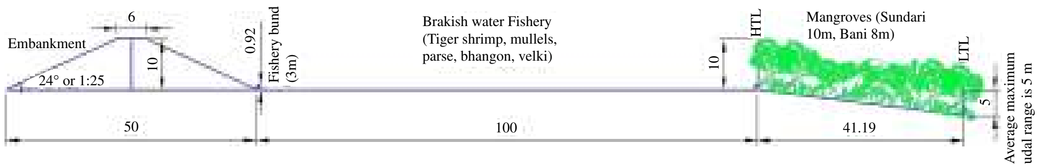

Figure 5. Cross section of proposed embankment, fishery and mangrove.

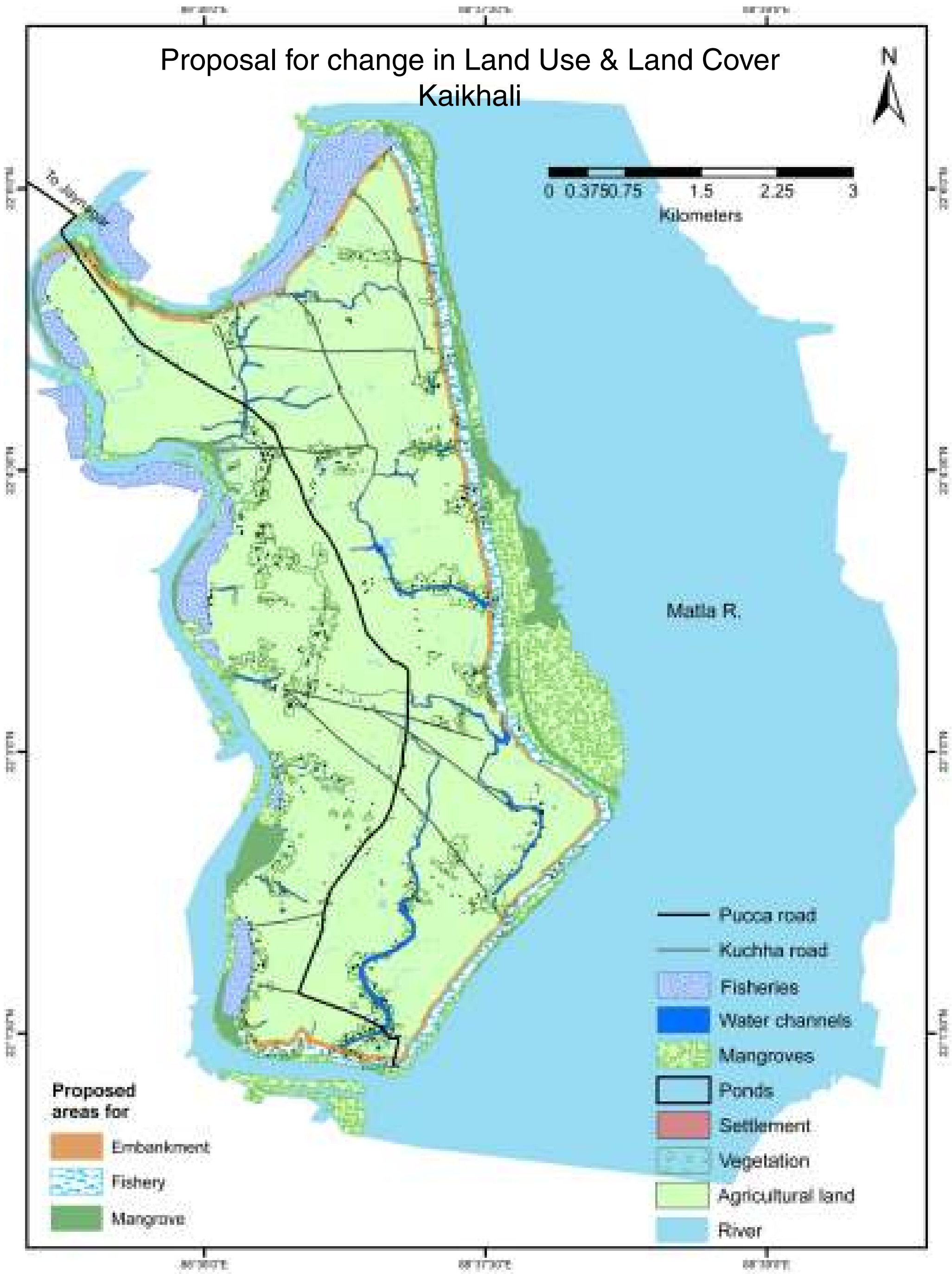

Figure 6. Changes in land use and land cover.

Location of flood shelter: Appropriate location of flood shelter alone can help save life to a large extent. (emphasized in the Flood management Plan by National Disaster Management Authority (NDMA), 2008). Apart from land use conversion building type and use of it also can help both disaster mitigation as well as socio-economic improvement. Hence, a functionally and topographically suitable location of flood shelter has been identified with the use of GIS and Remote Sensing. Functional suitability is defined by the fact

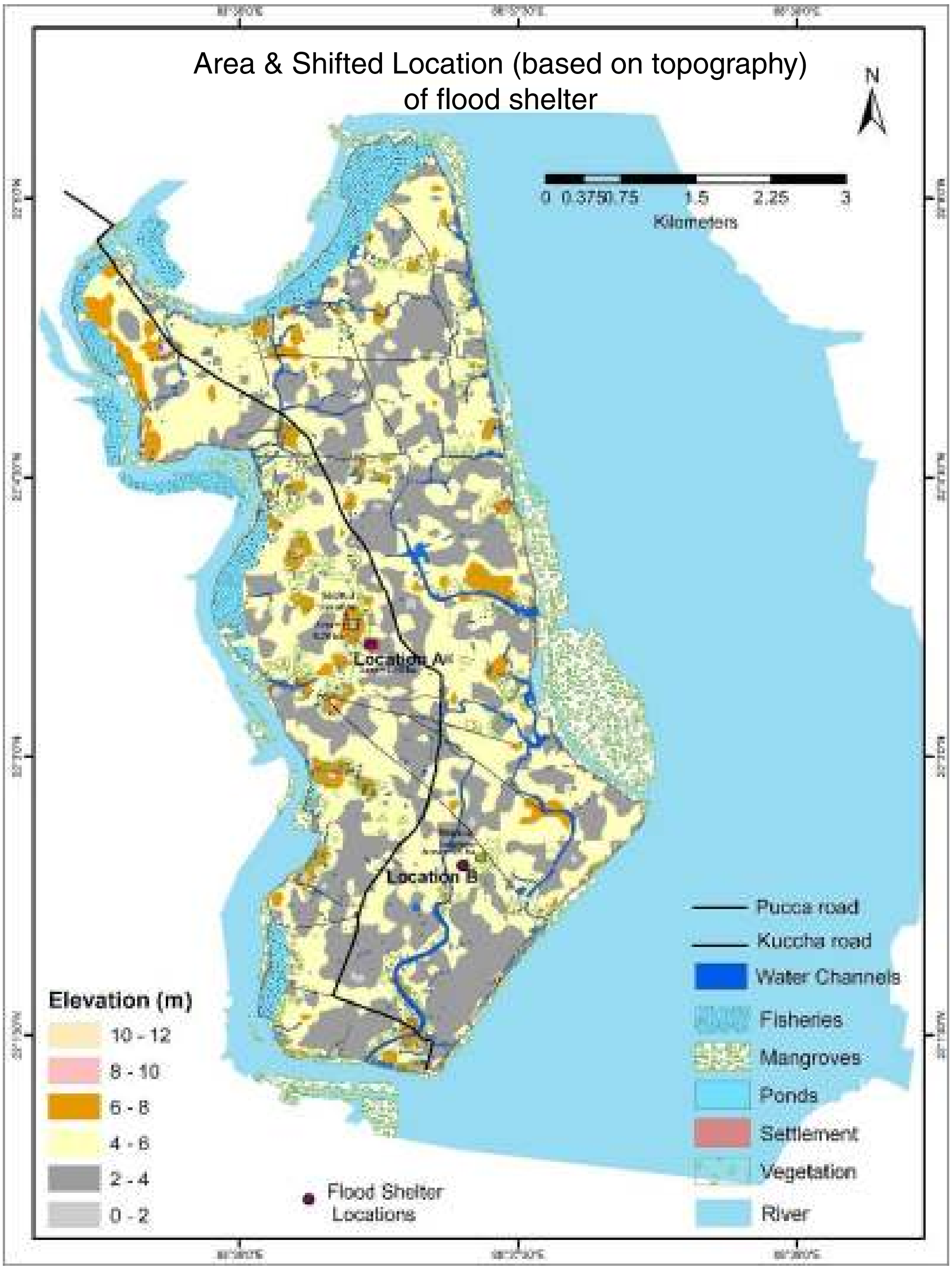

Figure 7. Topographically (adjusted) functionally suitable location for flood shelter and its area.

that maximum number of people could reach in minimum available response time (30 & 15 minutes) at a speed (4.8 km/hr) and stride length (1.4 feet) normal to an Indian women while walking. These assumptions have been taken considering the worst case scenario in case of failure of warning dissemination (normally 24 hours before disaster is likely to strike). However, the nature of flood shelter will be multipurpose i.e. school and computer training center at one location and health center in the other. The computer training center can be equipped with warning dissemination facilities connected to Alipore Meteorological Department and trained personnel from the village could be appointed for the same. This opportunity can be used to prepare an online database for the villagers wherein all their documents (BPL card, ration card, certificates) can be uploaded to keep them safe from flood & cyclone. Computer training to village youth will enhance their capability to work as other than farmers/fishermen. Presence of a school and health center will fulfill the need of basic amenities in the village to certain extent. Solar electrification of the village is also suggested which is a major drawback behind the failure of warning dissemination. Proper storage facility for essential commodities viz. water & dry food (chidwa, jaggery) can be done. Rainwater could be harvested (roof top) and stored in tanks. Villagers whose land would be acquired their able bodied person should be employed in

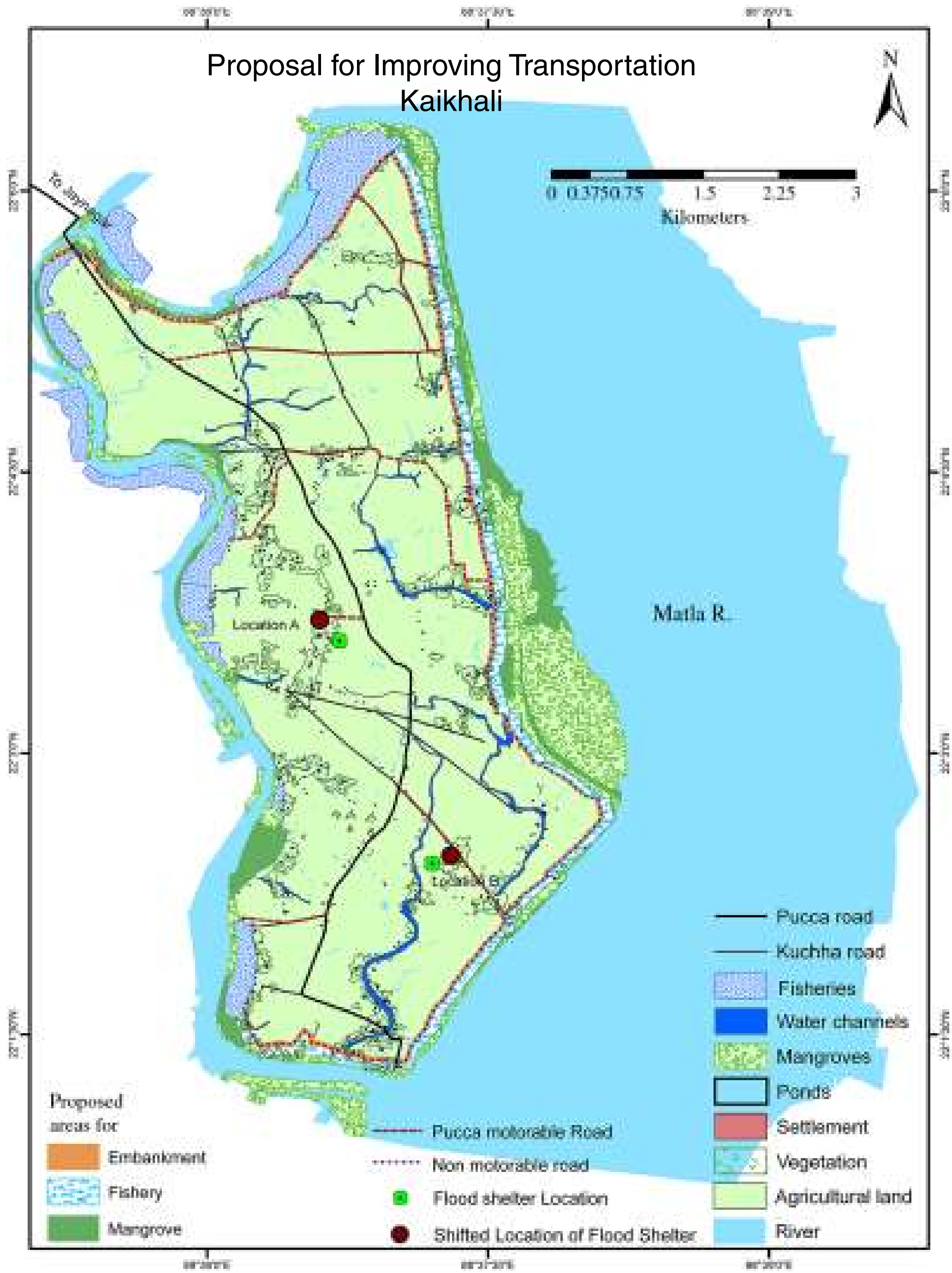

Figure 8. Proposal for motor able and non motor able road.

the maintenance of shelter (or as suitable) or in schools or dispensaries. However, the land under the stilts could be used for growing crop or vegetable species or fodder that can withstand shadow.

Methodology applied to locate the probable places involves mathematical function of centroid (Geometric center of a polygon), computed through Geographic Information System. The layer of dwelling units has been taken as the polygons. GIS in this process first computes centroids of each polygon (dwelling unit) then forms polygons passing through the existing centroids. This process continues till it comes down to one. When the function was run it gave four locations as a result. Out of which Locations A and B (Figure 7) being within the Island boundary has been considered for further validation based on criteria mentioned above and a buffer area was created with the radii of 1.2 km and 2.4 km (Distance = time × speed) that one can cover in 15 and 30 minutes respectively. Location A was found to cover 192 & 505 dwelling units and location B covered 162 & 497 dwelling units. Location A covers the maximum number of people 1091 & 2868 (Number of people per household being 5.68) and so can be preferred to Location B. Also because the West Bengal Tourism Departments' guest house is around 2 km away from B and has the potential to be resorted to during emergency. Based on topographic analysis nearest area with an elevation of 6 to 10 m has been chosen and accordingly Location A could be shifted 269 m NW and Location B could be shifted 194 m NE (Figure 7) of the original location. Compensatory plantation around flood shelter for the encroached vegetative area should be done. However building the shelter on stilts or shifting to a higher mound, which so ever seems feasible could be applied here.

Capacity of flood shelter has been decided based on sleeping space needed for future projected population of 13932 by 2021 & for 2121 cattle i.e. cows & buffaloes (2 buffaloes per household dependent on agriculture and one cow per household). Unit area required for cattle and human being to sleep is 1.7 sq. m and 3 sq. m totaling to 30047.4 sq. m or 3 Ha. If the building is 2 floors then floor area required would be = 1.52 ha. If required two buildings could be constructed one each in location A & B. The ratio of dividing the floor area between loc B and A is 1:1.04 i.e. A = .78 ha and B = .75 ha. This is based on an assumption that the population within the buffer areas of location A, B will increase in the same proportion as projected.

Improved Transportation: The rationale behind this set of proposal is that

➢ Better accessibility leads to better livelihood.

➢ Increased mobilization of people.

➢ Easy to market the fishery and agriculture products.

Mostly the footpaths have been proposed to be converted into motor able roads (6 m Right of Way) so as to connect the major clusters of settlements and fisheries along the island boundaries. Non motor able road is proposed on the top of the embankment (heavy or motor vehicle not allowed unless its strength to bear the weight is satisfied). It also connects the sites suggested for construction of flood shelter to provide better accessibility throughout the year (Figure 8).

6 Conclusion

Amongst all measures for mitigating flood it has been seen that *Open systems'* approach could work best in an active and ecologically sensitive delta as this. Mangrove restoration and its adjacency to brackish fishery could revive back a traditional system of livelihood that helped as well in combating flood and cyclone. It is often better to go back in the pages of history to dig out a solution scientifically thought of by our ancestors than to rely totally on contemporary higher technologies.

Another spatial measure that could save peoples' life and property and also help in post flood relief distribution is the proper location of a flood shelter. It is very essential that suitability is judged based on *functionality* (accessibility to maximum number in minimum time available) first because the advantage of topographic suitability can also be availed by constructing the building on stilts.

A *proactive approach* towards flood mitigation is better preferred today and has also been applied in this study in terms of improving peoples' livelihood by enhancing their income through measures like provision for alternative occupation, improved connectivity, formation of cooperatives etc.

All these measures to be successful, peoples' participation become the most essential thing. Steps like formation of users' association etc have the potential to save the natural ecology (mangroves, aquatic life etc.) and maintain the other measures taken like embankments, flood shelter etc.

Lastly, a rural area in coastal zone, often the most neglected one can be planned (with spatial techniques) to be a better place for the villagers to live in, free of worries (disaster). This was the ultimate attempt of the whole study conducted on "Reducing Vulnerability to Flood through Spatial Planning; Kaikhali Island, South 24 Parganas, West Bengal, Inida".

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Diaster management education in India

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ABSTRACT

Education is a fundamental human right and it is essential to ensure that all are able to realize their potential. A key aim of education is to give all citizens the necessary skills and values to improve their quality of life. To achieve this aim we shall continue to work together to improve access to education and to increase the quality of educational facilities in an equitable manner. The physical environment in which learning takes place has a large impact on the outcomes of education.No task is as important as creating safe learning environment for our nations children. Recent events of children deaths due to building collapse, fire accidents and stampede bring to light the need to be continually vigilant to ensure for safety of students and staff in schools. The event that unfolded in the Kumbhakonam fire tragedy which took the lives of 93 children reiterate the need to have school level emergency preparedness and response plans, schedule time in busy school day to practice drills to respond effectively and efficiently to disaster situation.

1 Introduction

The following is a poem penned by Dr A P J Abdul Kalam former President of India in memory of the children who died in Kumbakonam fire tragedy in Tamilnadu in a school in which 93 children died.

Oh dear little ones! Oh dear little ones!
For you, parents had glorious dreams!
And you were all immersed in your own dreams
Yet, Agni engulfed you and all of those dreams
Taking you to Almightys divine presence
Usually, departed old parents are buried by sons
Whereas, Kumbakonam, saw a sad scene!
Crying parents burying their little ones!!
Oh Almighty! Show your grace on those little ones
And keep them all in Thy Holiest Presence!!
Oh Almighty! Bless those parents wilting in grief
To have the strength to bear this great loss
May Thy compassion and grace pervade all souls?
And bring down the pain and wipe away the tears
Oh Almighty! Show your grace on those little ones.

Natural disasters have been visiting every part of the globe at one time or the other. The world is becoming increasingly vulnerable to natural disasters. From earthquakes to floods and famines, mankind is even more threatened by the forces of nature. Disasters can strike at any time, at any place. Nearly three million people worldwide may have been killed in past 20 years due to natural disasters such as landslides, earthquakes, floods, snow avalanches, cyclones etc. Ninety per cent of the natural disasters and ninety five percent of the total disaster related deaths worldwide occur in developing countries, in which India has the second largest share. Recognizing the need of the hour, the decade 1990–99 was declared as International Decade for Natural Disaster Reduction with a main objective to focus on disaster management planning for prevention, reduction, mitigation, preparedness and response to reduce the loss of life and property. India, a country with diverse geographical conditions, 70 per cent of the cultivable land is prone to drought, 60 per cent of the land area is prone to Earthquake, 12 per cent to Floods, 8 per cent to Cyclones, 85 per cent of the land area is vulnerable to number of natural hazards and 22 States are categorized as multi hazards States. Tens of thousands of people are affected by these natural disasters (Arya *et al.*, 2003; IDNDR 2001)

We have seen in the recent past that country suffered impact of earthquake even where the seismicity was low as per the seismic zoning map, as in the case of Maharashtra and droughts have occurred in the areas with highest rainfall i.e. Cherrapunji in the North

East. In spite of the best efforts by the Governments, external assistance and available technologies and media, the 1999 Super Cyclone of Orissa and 2001 earthquake of Gujarat have inflicted untold misery (Kapur *et al.*2005). The socio-economic backwardness of the majority of our population, coupled with lack of skills or for mitigating, preparing for and responding to disasters increases their vulnerability, negatively affecting their ability to respond and recover from periodic and intense disasters. Amongst all, the children in schools are the most vulnerable groups during any disaster. The lessons learnt clearly bring out the fact that no State, no Government can meet the challenges alone. The Governments effort have to be strengthened by communities themselves getting involved in the emergency response system and being aware of the dos and donts to be prepared for any eventuality. In the old literature too, disaster management finds mention in Kautilyas Arthashastra as a primary duty of the state. Disaster Management as a post disaster activity has been well established in India especially since independence. The novelty of the new approach lies in taking well-planned and timely proactive measures to prevent disasters, to prepare people to cope with disasters and to motivate them to safeguard their own lives, livelihoods and habitat. Not only in India but through out the world the initiative is started to include the disaster management in education and it proves its importance, some of the examples are quoted here:

Education authorities of Indonesia along with GTZ have developed materials and taught more than 33,000 school children about the causes and results of earthquakes, tsunamis and volcanic eruptions. The impact of this initiative was demonstrated at in May 2006, when an earthquake hit the Yogjakarta region of Indonesia. Although 5,000 people lost their lives, the figures would have been much higher had the children not learned at school what to do in the case of an earthquake, and had they not passed this knowledge on to their parents. The families sought protection in doorframes, under tables and under beds, and did not leave their houses until the quake was over. Such families escaped serious injury. An example is of the young Tilly Smith, who seeing the receding water before the tsunami could remember her geography lessons on tsunami and was able to save the lives of 100 tourists from a beach in Thailand in December 2004. (Source: Disaster Reduction: Knowledge,Transfer, Practice, Proceedings of the 7t Forum and Disaster Reduction Day, 2006.) Partho, a tweleve year boy from a village in Orrisa remembered the lesson learnt in the school regarding disaster preparedness at the time of the flood, and could save hundreds of lives to by utilizing this knowledge at appropriate time (World Disaster Report 2007). These and many more stories proved the importance of Disaster management and preparedness in terms of prevention. Many times not being aware of the hazard may put us in the disaster situation. Culture of prevention should be inculcated in our lifestyle to face the emergencies and to minimize the loss of life and properties.

2 Disaster prevention measures

Integrating disaster prevention with national development plan.

(i) Formulating a disaster management policy for the whole Country.

(ii) Making the community aware, educate and their capacities built to manage disasters.

(iii) Involving educational institutions, corporate sectors, and non-governmental organizations in eliciting public participation, generating awareness amongst all concerned stakeholders.

The High Powered Committee set up by the Govt. of India in August 1999 has outlined the following proactive measures to bring in the culture of prevention and techno-legal aspects.

(i) Capacity building in disaster management has to be at policy, institutional and individual level.

(ii) Enforcement of protection and prevention measures.

(iii) Proactive measures for disaster preparedness and mitigation should be administrative, financial, legislative and techno-legal.

(iv) Raising and recruitment of professionals to build up expertise for mitigation and management.

(v) Generating a proper understanding of risk between different stakeholders, training and confidence building among professionals and mason with appropriate development planning strategies.

(vi) Rehabilitation view as a long term phased activity (IGNOU 2006).

3 Disaster preparedness

Disaster preparedness is an effective way of lessening the impact of disasters, which occur on a small as well as large scale it acts as an effective link between emergency response and rehabilitation. The significance of developing disaster preparedness mechanisms and processes to neutralize and reduce the vulnerability of people and minimize loss of lives and property. The United Nations Disaster Relief Office (1998) defines disaster preparedness as measures designed to organize and facilitate timely and effective rescue, relief and rehabilitation operations. In cases of disaster Measures of preparedness include among others, setting up disaster relief machinery, formulation of emergency relief plans, training of specific groups, to undertake rescue and relief, stock piling supplies and earmarking funds for relief operations. Modern Dictionary of Disasters defines preparedness as, the aggregate of all measures and polices taken humans before the event occurs that allows mitigation of the impact caused by the event. Preparedness includes warning systems evacuation, relocation, of dwellings, stores of food and water, temporary shelter, energy management strategies, disaster drills and exercises etc. Contingency plans and responses are included in the preparedness (Singh and Sharma 2005).

4 Disaster management and education in India

Indias vision in disaster management is to build a safer and disaster-resilient country by developing a holistic, proactive, multi disaster and technology-driven strategy for disaster management through collective efforts of all Government Agencies and non-governmental organizations (www.ndma.gov.in). There has been a paradigm shift in the disaster management approach from relief-centric/crisis management to prevention, mitigation and preparedness. Education for disaster management is a trans-disciplinary exercise aimed at developing knowledge, skill and values at all level. Government of India in its Tenth and Eleventh Five Year Plan document, have emphasized the need to enhance knowledge, skill and values to reduce the impact of disasters on the education sector. Some of the recent disasters that have affected the education sector in India are the Gujarat earthquake (2001) where 971 students and 31 teachers were killed, 1,884 schools collapsed; Tamil Nadu Fire (2004) incident where 93 children died in a fire due to explosion of a cooking gas cylinder; North Pakistan, Kashmir earthquake (2005) where 17,000 students died at school, and 10,000 school buildings destroyed, no one can forget the school in Leha washed out in cloud bursting with many children recently (Anon 2005, 2006). To build in a culture of safety and resilience at all levels in the education sector, there is a need to carry out a large number of initiatives. Prevention is better than cure, is an old saying which is very apt in the context of disaster management. Every year colossal amount of resources is used by our Government as well as Aid agencies in relief and rehabilitation measures. It is now becoming increasingly evident and mitigation and investment in disaster preparedness can save thousand of lives, vital economic assets, livelihoods and reduce the cost of overall disaster relief. Government of India, Ministry of Human Resource Development in its Tenth Five Year Plan emphasized the need for integrating disaster management in the existing education system in India. In addition, the government of India launched a set of nation-wide disaster risk mitigation initiatives that addresses larger aspects of development in order to safeguard the developmental gains. One of the important initiatives includes disaster management in the curriculum of school and professional education has been recommended to the Boards. Educational Institutions can contribute towards generation of knowledge in the area of disasters, develop expertise in specific types of disaster and impart training in different fields. Disaster awareness education in educational institutions has the following advantages:

(1) It provides contemporary and relevant information about local environment.

(2) It prepares for participation in both pre and post disaster activities of the affected/vulnerable community on a wider scale.

(3) It contributes past experience with recent developments in technology to combat disaster.

(4) It helps to develop effective domain abilities for collective work as successful disaster management efforts involve an effective teamwork and spirit.

(5) It promotes informed decision-making in the event of a disaster.

5 Five year plans and thought on disaster Management education

The Tenth plan (2002–2007) document outlined the need for preventive planning, which is intrinsically linked to disaster prevention. The prevention measures tend to be large due to the varied nature of disasters. Prevention along with appropriate preparedness and mitigation measures shall prove effective. The multi-sectoral and multi-hazard prevention based approach to Disaster Management requires specific professional inputs. Professional training in disaster management should build into the existing pedagogic research and education. Universities and professional teaching institutions may develop specialized courses for disaster management, and disaster management should be treated as a distinct academic and professional discipline, something that the American education system has done successfully. In addition to separate diploma/degree courses in disaster management, the subject needs to be discussed and taught as a specific component in professional and specialized courses like medicine, nursing, engineering, environmental sciences, architecture, and town and country planning. The focus towards preventive disaster management and development of a national ethos of prevention calls for an awareness generation at all levels. An appropriate component of disaster awareness at the school level will help increase the awareness among the children and, in many cases, parents and other family members through these children. Curriculum development with a focus towards dissemination of disaster related information on a sustained basis, The different school boards in the country may work out middle and high schools involvement in Disaster Management.

The above quotation from the tenth plan document clearly indicates the importance of disaster management in school education. The Eleventh Five Year Plan Suggests, The Investments in Disaster Education, Public Awareness, Community Leadership Development, Disaster Education of Unemployed youth, physically challenged, elderly, women and school children are essential. A large number of professionals require training and retraining for which we will have to generate quality teachers, quality text books, quality training kits, etc. This will call for innovation in disaster education, effective use of multi-media and self-education in different vernacular languages. All knowledge based institutions may be encouraged to give priority to such initiatives. This will call for innovation in disaster education, effective use of multi-media and self-education in different vernacular languages. All knowledge-based institutions may be encouraged to give priority to such initiatives.

6 Transfer the thought into policy

It is essential to ensure that the National DM policy highlights the need for integrating disaster risk reduction into the national curriculum and assigns the responsibility to the Ministry of Education. This ministry is responsible to:

- Designate a disaster management focal point in the Ministry and its agencies
- Develops departments emergency management policy and operational plans, including guidelines for schools to prevent and minimize emergencies and include disaster awareness training in school programs.
- Responds to advice from NC relative to safety of school children
- Provides on-site assistance and support for management of local issues involving parents, staff, students and media during emergencies
- Makes available, if required, school buildings as temporary welfare and evacuation centers in times of emergencies
- Provides staff as administrative managers of school buildings being used as welfare and evacuation centers
- Coordinates with other agencies in informing people of impending disasters, especially in remote areas
- Assists, where possible, in assessment of damage

as we all accept that most of our potential population is spending their most valuable time in the educational institutions National policy on Education also give the thrust on safe and secure environment of educational institutions, not only for students but the neighborhood community must feel the belongingness with these institutions (Parasuraman and Unnikrishnan 2000). Educational Institutions can contribute towards generation of knowledge in the area of disasters, develop expertise in specific types of disaster and impart training in different fields. Disaster awareness education in educational institutions has the following advantages:

(1) It provides contemporary and relevant information about local environment.

(2) It prepares for participation in both pre and post disaster activities of the affected/vulnerable community on a wider scale.

(3) It contributes past experience with recent developments in technology to combat disaster.

(4) It helps to develop effective domain abilities for collective work as successful disaster management efforts involve an effective teamwork and spirit.

(5) It promotes informed decision-making in the event of a disaster.

Most of the studies on the disaster management focused on to analyze the impact of disasters and stressed on the role of Govt., NGOs, Armed Forces etc. but do not speak about the education institutions were more than 35% of the population is spending their most precious span of time in these institutions. It is a need of the hour to think study and plan properly for total inclusion of the educational sector in the mainstreaming of the process.

7 CBSE initiatives in disaster education

In a first ever attempt by any educational institution in the country, the Central Board of Secondary Education (CBSE) has integrated a short course on Disaster Management in the school curriculum. With nearly 85 per cent of the land area prone to disasters it is high time the younger generation is prepared to combat disasters. Education in Disaster Management. With more than 7300 schools affiliated to it CBSE is one of the largest institutions of its kind in the country. The Boards examinations are taken by over 900,000 students annually! At the school level the CBSE realizes the importance of Disaster Management and School Safety. Educational institutions like secondary schools have a great role to play as schools imparts and play a very significant role in the all-round development process of the learners, this is the age where one can form, develop certain behavior patterns, attitudes, values as well as one can realize the responsibility towards the society. During the school education, learners can become aware and getting opportunity to understand the intensity of social situations and problems to prevent or mitigate them so that social, psychological and economical loss can be minimized. Disasters bring along with them heavy loss to life, property and livelihoods it is time to make disaster management a way of life-and an essential life skill.

8 Disaster management institutions in India and higher education

National Disaster Management Authority, Govt. of India (GOI) is the apex body for natural disaster management and mitigation in India. For effective implementation of relief measures in the wake of natural calamities, the GOI has set up a Standing National Crisis Management Committee under the chairmanship of Cabinet Secretary GOI. A Natural Disaster Management Control Room has been set up at Krishi Bhavan, New Delhi.ääFor planning for disasters and Emergency preparedness training, Government of India has created few institutes that offer short-term courses. The Disaster Management Institute, Bhopal set up after the gas tragedy conducts awareness programs for NGOs and the public at large. Universities have recently taken the initiative to introduce a few courses. For instance, IGNOU offers certificate and PG Diploma course in Disaster Management, the Mahatma Gandhi University at Kottayam, Kerala was the first state University in India to introduce a full-time 2-year MSc in Disaster Management, in 2008. The University of Pune offers a 6-month certificate course. The Indian Institute of Ecology and Environment, New Delhi offers another correspondence program in disaster mitigation in affiliation with the Sikkim Manipal University. The PRT Institute of Postgraduate Environmental Education and Research also offers a similar course in affiliation with the Institute of Open and Distance Education, Barkatullah Vishwavidyalaya, Bhopal. National Civil Defense College and National Fire Engineering College at Nagpur provides skill-based training in this field. In the field of higher education institutions like IITs and IIMs and some of the medical colleges include Disaster Management in their syllabus. Tata Institute of Social Sciences has a separate disaster department dealing with post graduate and doctoral program. RTM. Nagpur University includes Disaster Management as an elective option in Social Work Course Curriculum for Post Graduate degree. The policy making institutions in the field of Higher Education like UGC, NAAC, AICTE, Council of Architecture, National Programme for Earthquake Engineering Education and all the Universities imparting Distance Education Programme can initiate the process of inclusion of disaster management as a mainstream discipline of educational programme.

Disaster Management Education in India is still in its infancy and needs to be taken out from the classroom to the open community and from formal education sector to the informal sector and onto the entire community..So it is time to make disaster management a way of life-and an essential life skill. Let us join to make disaster resilient world with the culture of prevention and safety.as Honble — Kofi Annan, quoted in the Annual Report of the United Nations Organization More effective prevention strategies would not only save tens of billions of dollars, but tens of thousands of lives. Funds currently spent on intervention and relief could be devoted to enhancing equitable and sustainable development instead, which would further reduce the risk of war and disaster. Building a culture of prevention is not easy. While the costs of prevention have to be paid in the present, their benefits lie in a distant future. Moreover, the benefits are not tangible; they are the disasters that did not happen.

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Remote sensing and GIS based seismic sub-zonation in north-western Tamilnadu

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ABSTRACT

There are 4 major seismic zones (zones II, III, IV and V) in India, based on the seismotectonic parameters, history of seismicity and certain geophysical parameters. Accordingly, most parts of northern and western Tamilnadu are categorized under zone III, while the other parts fall under zone II. Since such a broad classification system will lead to regional level instead of local information for efficient disaster management, there is a necessity to have sub-classes. This paper attempts to study the northern and western districts of Tamilnadu (Chennai, Thiruvallur, Kanchipuram, Cuddalore, Villupuram, Vellore, Dharmapuri, Salem, Erode, Tiruvannamalai and Coimbatore) and arrive at a map that indicates sub-classes of seismic zones in these districts.
The factors considered for this study include: fractures/lineaments, history of earthquakes, and magnitude of earthquakes, Peak Ground Acceleration (PGA) and lithology. The input from remote sensing includes the use of satellite images to map the fractures, lineaments and lithology for the districts considered. The GIS based study involved both buffering and layer analysis. Buffering was used to demarcate the proximity of settlements to lineaments, while layer analysis involved assigning appropriate weights and ranks to the themes and preparation of the final zonation map. The result is a map indicating sub-classes/areas with high, moderate and low probabilities of seismicity within zones II and III of the north-western districts of Tamilnadu. Thus, it is seen that towns such as Arakkonam, Tirupattur, Katpadi and Ambur (belonging to the district of Vellore), which were hitherto categorized under Zone III, can now be categorized as: Arakkonam-*Zone III low*, Tirupattur-*Zone III low-medium*, Katpadi-*Zone III medium-high* and Ambur-*Zone III high*. Similarly, the other towns and villages can now be categorized into sub-classes. Thus, it is seen that such a remote sensing and GIS based analysis can help in prioritizing preventive measures to be taken for earthquake hazard mitigation and management in these districts.

1 Introduction

Earthquakes are caused mostly by rupture of geological faults, volcanic activity, landslides, mine blasts, and nuclear experiments. At the earth's surface, earthquakes manifest themselves by shaking and sometimes displacing the ground.

Seismic zonation is a policy tool for reducing vulnerability created by the intersection of the community's hazard, built and policy environments. The seismic zonation map gives basic guidelines for any region to know the hazard scenario and if any city or urban population is under threat from the seismic point of view. Large scale seismic zonation of a region is useful both to develop methodologies to support seismic risk reduction measures and to program an effective prevention plan. Seismic microzonation is defined as the process of subdividing a potential earthquake prone area into zones with respect to some geological and geophysical characteristics of the sites such as ground shaking, liquefaction susceptibility, landslide, rock fall hazard and earthquake-related flooding, so that seismic hazards at different locations within the area can correctly be identified. Microzonation provides the basis for site-specific risk analysis, which can assist in the mitigation of earthquake damages.

Regional geology and geotechnical properties of soil can have a large effect on the characteristics of ground motion. Thus, the site response of the ground motion may vary within a region according to the local geology and soil conditions. A seismic zonation map for a whole country may, therefore, be inadequate for detailed seismic hazard assessment of large regions. This necessitates the development of microzonation maps for big cities for detailed seismic hazard analysis. Microzonation maps can serve as a basis for evaluating site-specific risk analysis, which is essential for critical structures like nuclear power plants, subways, bridges, elevated highways, sky trains and dam sites. Thus seismic microzonation can be considered as the preliminary phase of earthquake risk mitigation studies.

The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). According to the new map more areas of Tamil Nadu are susceptible to damage from earthquakes than previously thought. Districts in the western part of the state, that lie along the border with Kerala lie in Zone III, along with districts along the border of Andhra Pradesh and a section of the border with Karnataka. The maximum intensity expected in these areas would be around 7. The rest of the state lies in Zone II. Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 AD), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated. Because of the above reason, there is an increasing demand for studying earthquakes in this region and create a zonation map that indicates SUB-ZONES within ZONES II and III. Apart from this aspect, the north and the western regions are more prone to earthquakes. To study the impact of earthquakes on the demography of these regions, microzonation is necessary.

This paper presents the results of an attempt to define sub-classes within the Zones II and III in Northern and Western Tamilnadu. Certain maps used in this study were adopted from the article entitled 'Seismic hazard assessment based on attenuation relationship for Tamilnadu state, India' (Rajarathnam *et al.* 2001). Satellite images were sources for additional data and GIS was used as a data input and analysis tool.

2 Remote sensing and GIS in seismic studies

Remote sensing has been used for earthquake research very early, with the first appearance of satellite images. First of all it was structural geological and geomorphological researches. Active faults and structures were mapped on the base of satellite images (Trifonov, 1984). Remote Sensing and GIS also provide us with tools to carry out disaster management planning. The assessment and demarcation of earthquake affected area can be done through quick aerial photography after an earthquake. Classification of damaged areas into worst, moderate and least affected areas can be done through the use of different colour tones on the satellite imageries and aerial photographs. Safe habitation zones can be demarcated with the help of structural deformities visualized through satellite imagery taken after the earthquake. Usually these areas would be plain open areas free from crustal fractures, ruptures, folds etc. In this study, we have employed remote sensing and GIS for generating and analyzing the various thematic maps. The maps containing the lineaments and lithology were obtained with the aid of remote sensing. The maps thus obtained were digitized using GIS. Then, the final overlay analysis was done in combination with information on earthquake magnitude, PGA, etc. A Geographic Information System (GIS) captures, stores, analyses, manages, and presents data that is linked to geographic location. Data source for a GIS typically include maps and remote sensing system, both of which are capable of producing large volumes of data. The use of GIS in seismic hazard assessment is now widespread, allowing the integration of disparate digital datasets into a single, unified database. Using of GIS in seismic hazard mitigation, is a favorable way for studying immense amount of data which can reduce budget and time and limit the area of exploration and getting better results. The need to include ancillary information (e.g. maps and ground surveys) in the process of interpreting remotely sensed data has long been acknowledged by the remote sensing community.

3 Area of study

As stated earlier, the state of Tamil Nadu falls under the seismic zones II and III. The area of study chosen by us includes the north and western regions of Tamil Nadu. The districts included in our study are-Chennai, Thiruvallur, Kanchipuram, Cuddalore, Villupuram, Vellore, Dharmapuri, Salem, Erode, Tiruvannamalai, Nilgiris and Coimbatore (Figures 1, 2) . The study falls under both ZONE II and III. These districts have been chosen because of the following reasons: (i) There have been frequent seismic episodes in these districts compared to the other districts (see Table 1). (ii) Many faults and lineaments are present here compared to other districts; and (iii) Population, industrial activity and infrastructure are higher than other districts.

In the study area, siesmicity has been reported and recorded for the past two centuries. The following table lists these events.

4 Methodology

The methodology adopted in this study includes three components viz Satellite image interpretation, Digitization and importing the thematic maps into a GIS and

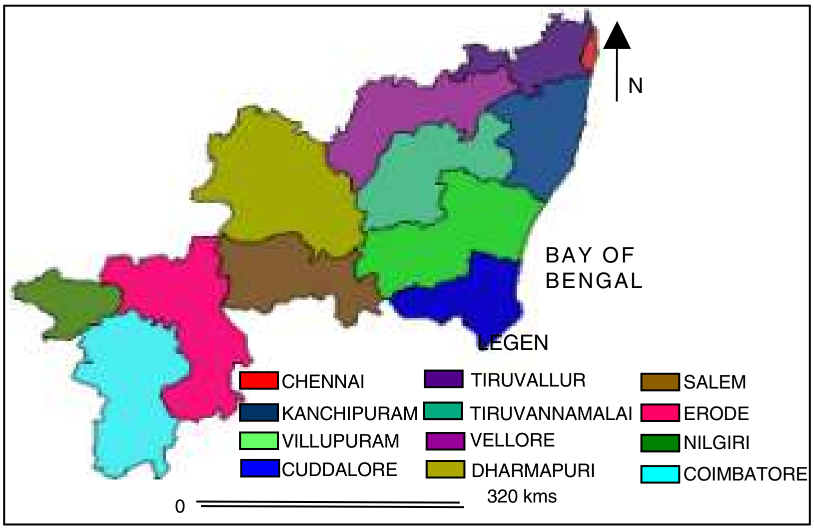

Figure 1. Map of study area showing the northern and western districts of Tamilnadu.

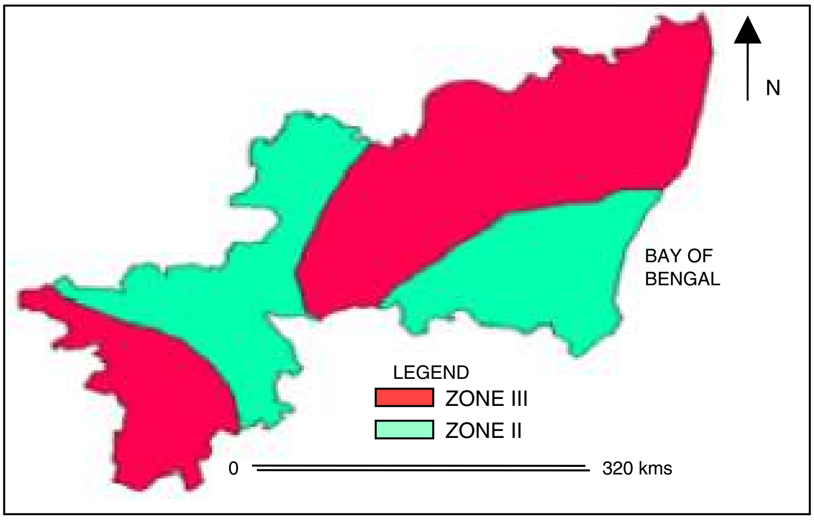

Figure 2. Map showing the major seismic zones in northern and western Tamilnadu.

GIS analysis (Figure 3). First, the various factors influencing the seismicity of our area of study are identified. They are- lithology of the area, the peak ground acceleration (PGA) of the region, the fractures, faults and lineaments in this region, the past history of earthquakes in north and western Tamil Nadu and the magnitude of these earthquakes. Since the fractures and faults in an area primarily control the seismicity (frequency and intensity), it is pertinent to prepare an accurate and updated map. So is the case with lithology. Hence the Landsat ETM+ False Colour Composite was interpreted and a lineament map was prepared. The following factors were helpful in identifying lineaments/fractures: (i) straight river courses, (ii) alignment of ponds, lakes and tanks, (iii) offset of streams and rivers, (iv) linear dykes and ridges, (v) offset of rocks, (vi) abrupt change of soil and rock tone, and (vii) abrupt change in stream or river course. The lithology map was interpreted from the FCC based on the tonal, textural and drainage characteristics of the rocks. Existing lithological maps published by GSI (1995) was used for verification. The other maps and collateral data were collected from various sources. Then, using the data collected, we digitized the maps in a Geographical Information System (GIS). The different maps that were digitized are: the lineament density map, the PGA map, the geological map, and the magnitude range map. The different layers, thus generated are used in the final overlay analysis. From the past history of earthquakes, it is clearly seen that, barring a couple of earthquakes, it is the north and western regions that are more seismic prone than the other regions. This is another reason to study the seismicity of this region at micro-level. It can also be noted that the north and western regions are more densely populated than the other parts of the state. This is yet another reason why microzonation of this region is a necessity, as these regions are more hazard-prone.

5 Ranks and weights

Weighted overlay is a technique for applying a common scale of values to diverse and dissimilar input to cre-

Table 1. Seismic history of the study area for the past two centuries (Source: Rajarathinam *et al.* 2001).

S.No	Date	Intensity	Place	Latitude	Longitude
1	10th Dec 1807	5.0	Chennai/off the coast	13.100	80.300
2	16th Sep 1816	5.0	Chennai/off the coast	13.100	80.300
3	29th Jan 1822	5.0	Thirukkovilur, Villupuram	12.000	79.000
4	29th Jan 1822	5.0	Vandavasi, Tiruvannamalai	12.500	79.700
5	2nd Mar 1823	5.3	Sriperumbudur-Chettipattu, Chennai	13.000	80.000
6	3rd Jan 1859	5.0	Polur, Tiruvannamalai	12.500	79.000
7	2nd Aug 1865	5.7	Vaniyambadi, Vellore	12.700	78.700
8	3rd July 1867	5.7	Vikravandi-Valavanur, Villupuram	12.000	79.600
9	28th Feb 1882	5.7	Ooty,Nilgiris	11.460	76.600
10	12th Aug 1889	5.0	Chennai	13.100	80.300
11	8th Feb 1900	6.0	Waliyar/Coimbatore	10.800	76.800
12	29th July 1972	5.0	Eastern section/Coimbatore	11.000	77.000
13	26th Sep 2001	5.6	Coastal TN, near Pondicherry	11.984	80.225

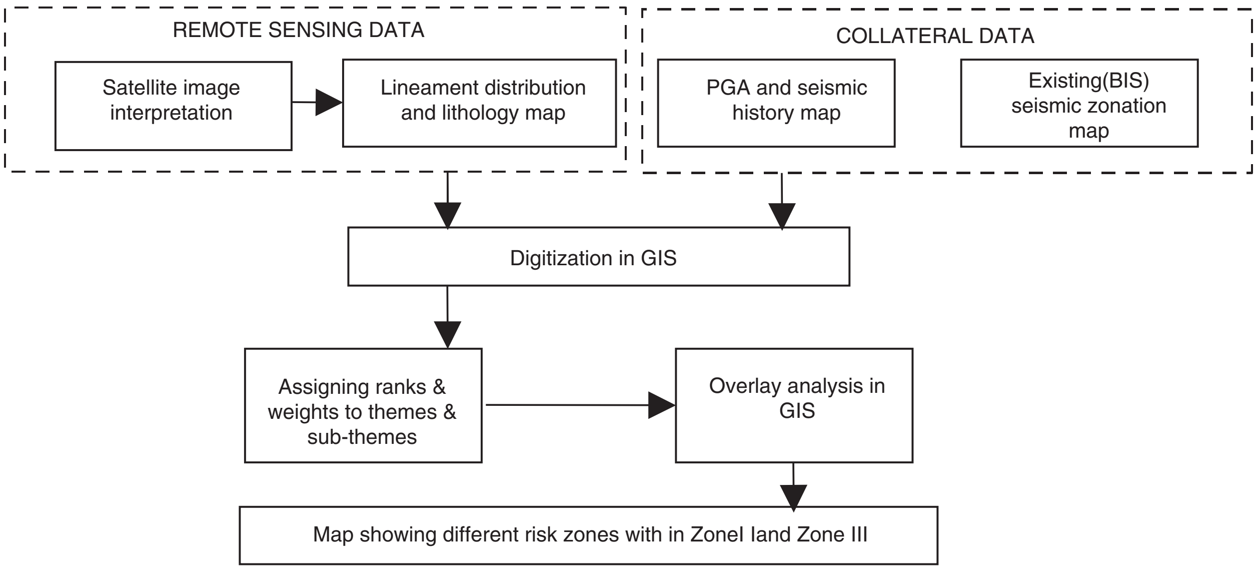

Figure 3. Flowchart of methodology.

ate an integrated analysis (Arc GIS 2008). Wieghted Index Overlay Analysis (WIOA) is a simple and straightforward method for a combined analysis of multi-class maps. A weight represents the relative importance of a parameter with respect to the objective. WIOA method takes into consideration the relative imporatance of the parameters and the classes belonging to each parameter (Saraf and Choudhury 1998). Topology creation and error removal has to be done prior to this. Topology is used most fundamentally to ensure data quality and allow the geodatabase to more realistically represent geographic features. In the current study of identifying subclasses, the thematic maps are analysed by overlaying and ranks and weights are assigned to each category in the theme to model the probable sub-classes. The input layers to the weighted overlay are lineament distribution, magnitude range, PGA values, and lithology.

Determination of weights to each class is the most crucial in integrated analysis, as the output is largely dependent on the assignment of appropriate weight. The ranks and weights assigned to each theme and sub-theme are listed in Table 2. These parameters have been used in the overlay analysis to finally arrive at the zonation map that indicates the sub-classes within the ZONES II and III in the study area.

6 Results and discussions

6.1 GIS analysis

The various thematic layers generated using remote sensing and GIS are presented below in the Figures 4 to 7. The description for each of the themes is as given below:

Lithology: Lithology is the scientific study of rocks, usually with the unaided eye or with little magnification. It gives information about the structure and composition of a rock formation. The **lateral variations in lithology controls the**

Table 2. Table showing ranks and weights assigned to various themes and units.

Theme	Weight	Units	Rank	Remarks
Lineament Distribution	9	High	5	Higher number of lineaments indicates more probability of seismicity
		Moderate-high	4	
		Low-moderate	3	
		Low	2	
		Nil-very low	1	
Lithology	7	Alluvium & clay, laterite, sandstone	2	Low density rocks; hence less seismic-prone
		Granite gneiss, pink granite	6	Moderately dense; hence moderately seismic-prone
		Charnockite	7	High density; hence seismic-prone
Magnitude Range	8	5–6	5	High earthquake intensity for previous earthquakes indicates a higher probability of seismicity in future
		4–5	4	
		3–4	3	
		2–3	2	
		<2	1	
PGA values	7	0.236	5	Larger the values, higher is the ground shaking. Hence higher is the risk.
		0.210	4	
		0.192	3	
		0.155	2	
		0.146	1	

depth (and thus the magnitudes) of potential future earthquakes; these depths can be determined from the depth of the background seismicity.

The area of study has the following major types of rocks- Granite gneiss, Charnockite, Clay, Limestone, Pink granite, Laterite, Cuddalore sandstone (Figure 4). Of these, on analysis, it is seen that granite gneiss is present in most of the places. The regions that contain this rock type are- Erode, Coimbatore, Salem, Villupuram and parts of the districts of Dharmapuri, Vellore, Tiruvannamalai and Tiruvallur. Pink granite is present in a very small quantity. Only a few parts of Coimbatore, Salem, Erode, Tiruvallur and Kanchipuram contain pink granite. This rock type doesn't play a big role as far as the seismicity is concerned. The Nilgiris completely has Charnockite rocks, and it is also present in parts of Erode, Dharmapuri, Vellore, Salem, Tiruvannamalai, Kanchipuram and Villupuram. Next to the granite-gneiss variety, maximum earthquakes occur in the region that has this rock variety. The Alluvium variety is spread along the coastal regions of the districts considered i.e. along the coast of Chennai, Cuddalore, Vellore, Kanchipuram, Tiruvannamalai and Tiruvallur. The other rock types such as clay, Cuddalore sandstone and laterite are present in very small quantities and do not contribute much to the seismicity of the region.

Magnitude Range: The magnitude range of the past earthquakes in the study area is from 2 to 6. It is observed that earthquakes of maximum intensity of 5–6 have occurred in the districts of Villupuram, Tiruvannamalai, Kanchipuram, and in a few parts of Tiruvallur, Vellore, Nilgiris and Coimbatore. Salem and Dharmapuri fall under the magnitude range of 4–5, while a few parts of Dharmapuri, Coimbatore, Salem, Villupuram and the majority of Chennai come under the 3–4 magnitude range. Cuddalore, which has a terrain made-up of Cuddalore sandstone, has a magnitude of just 2–3 (Figure 5).

Peak Ground Acceleration (PGA): (PGA is a measure of earthquake acceleration on the ground and an important input parameter for earthquake engineering. Unlike the Richter magnitude scale, it is not a measure of the total size of the earthquake, but rather how hard the earth shakes in a given geographic area. The peak ground acceleration can be defined as maximum acceleration in earthquakes on firm ground after high frequencies that do not affect sizeable structures(large houses, factories, bridges and so on). It can also be termed as the intensity of ground shaking. From the digitized map of the area of study, it is seen that there are five major PGA values (Figure 6). These are: 0.236, 0.21, 0.192, 0.155 and 0.146. The region with the maximum Peak Ground Acceleration (PGA) is more seismic prone than a region with smaller PGA values. It is seen from the analysis of the map that the region with the maximum PGA in our study area is the Nilgiris. The PGA value is 0.236. This is one reason why the Nilgiris are prone to earthquakes. The region which comes next includes Chennai, Tiruvallur and Parts of Kanchipuram. They have a PGA value of 0.21 and are also prone to a higher level of seismicity than the neighboring districts. Next is the region with a PGA of 0.192. This region includes Villupuram, parts of Kanchipuram, Cuddalore, parts of Tiruvannamalai, Coimbatore and Vellore with a moderate level of seismicity. The remaining PGA val-

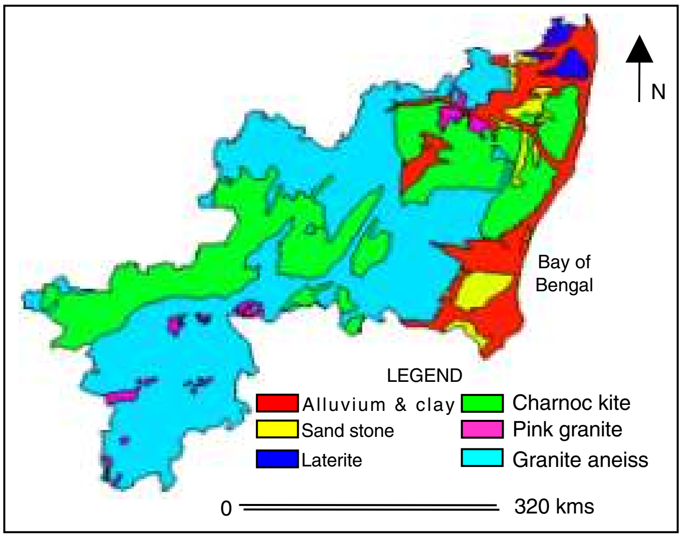

Figure 4. Map depicting the lithological units in the study area (source: GSI 1995).

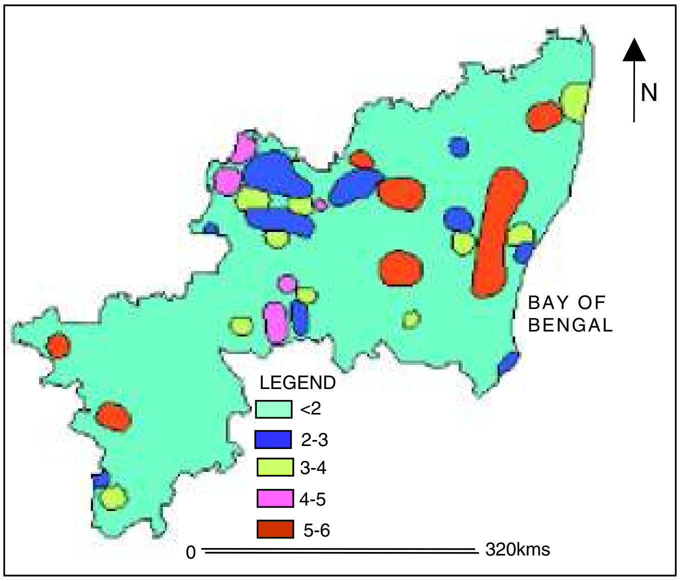

Figure 5. Map showing the magnitude range for past earthquakes (source: GSI 1995).

ues are lower than the others. Of these two values, the region with a PGA value of 0.155 consists of Vellore, Dharmapuri and Salem. Then we have the region with the lowest PGA values, encompassing the districts of Cuddalore, Erode, Salem, etc.

Lineament Distribution: The lineament distribution over the area of study can be widely classified into four categories as follows-low, low-moderate, moderate-high and high (Figure 7). The entire region can thus be divided on the basis of these lineament densities. The region with the low lineament density consists of the districts of Dharmapuri, Salem, and small parts of Tiruvallur and Tiruvannamalai. These districts also fall under the region with minimum PGA values. Next we have the low-moderate lineament density. The district of Dharmapuri alone comes under this category. In the moderate-high density group, we have the districts of Coimbatore, the Nilgiris, Cuddalore, Villupuram, Kanchipuram, Tiruvannamalai and the majority of Chennai. These are regions with a higher PGA value. Next, we have the high lineament density area. The districts in this region are more seismic prone than the other districts in the area of our study. These districts are Salem, Dharmapuri, Villupuram, Cuddalore, Vellore and Tiruvannamalai.

7 Result

The result of the overlay analysis, using the above mentioned ranks and weights for various themes and sub-themes is a map that shows sub-classes within the BIS designated zones II and III. These sub-classes are listed in Table 3. The final output is as shown in the Figure 8.

On doing the final overlay analysis using GIS, it is seen that, although the state of Tamil Nadu is divided

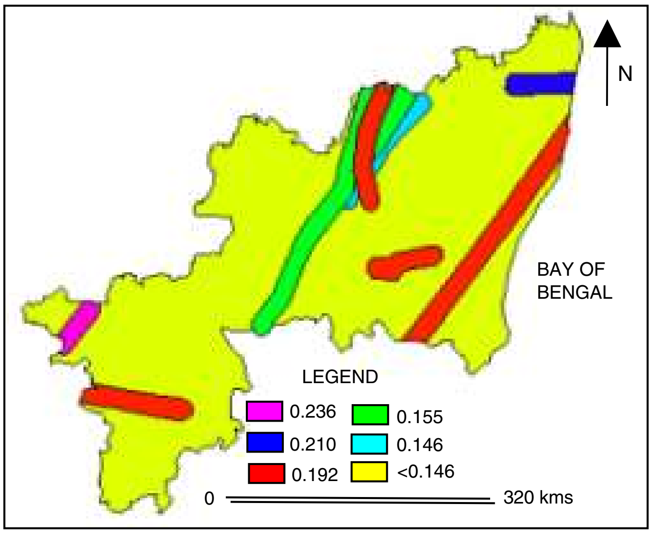

Figure 6. Map showing the distribution of PGA in the study area (Source:GSI 1995).

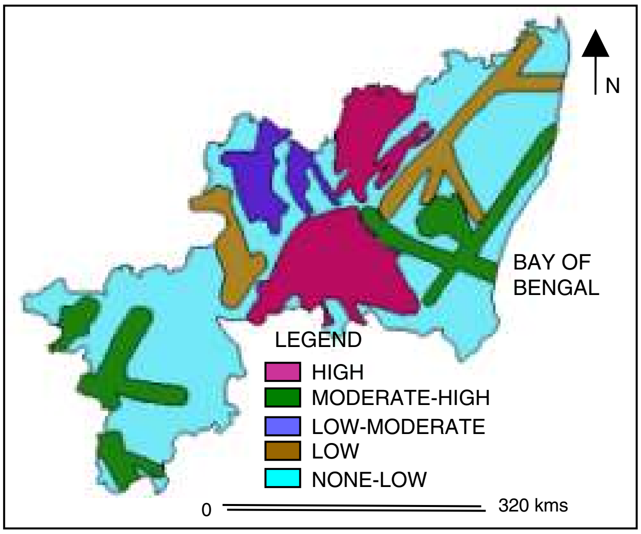

Figure 7. Map showing the lineament distribution in the studyarea (source: GSI 1995).

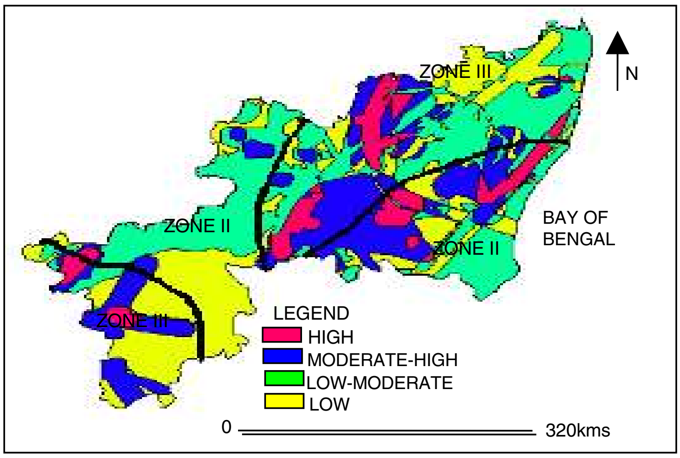

Figure 8. Map of the overlay analysis in GIS showing the various sub-classed within the ZONES II and III.

into two major seismic zones II and III, there are various sub-zones within these main zones. These show that even within each zone, there are zones that are more prone to seismic activity than the others. Figure 8 gives a more clear-cut idea. From the above figure, information listed in Table 3 has been deduced. It is seen that

Table 3. Sub-Zones within the ZONES II and III.

Zones	Sub-Zones	Districts
II	High	Villupuram with the towns Tindivanam & Sankarapuram
	Moderate-high	i) Dharmapuri with the towns Hosur & Palakkodu, ii) Salem with the towns Sankari & Edapaddi and iii) Villupuram with the towns Kallakurichi & Gingee.
	Low-moderate	i) Erode with the towns Sathyamangalam & Bhavani, ii) Cuddalore with the towns Kattumarankoil, Chidambaram & Cuddalore and iii) Dharmapuri with the towns-Denkanikottai & Krishnagiri.
	Low	i) Erode with the towns Gobichetipalayam, Perundurai & Erode, ii) Cuddalore with the towns of Virudhachalam and Kurinjipadi.
III	High	i) Nilgiris with the towns of Udhagamandalam and Kotagiri, ii) Vellore with towns of Vellore (district HQ), Ambur and Vaniyambadi, ii) Salem with the towns of Salem (district HQ), Yercaud and Omalur and iii) Coimbatore with the town of Coimbatore South.
	Moderate-high	i) Coimbatore with the towns Coimbatore North and Sulur, ii) Nilgiris with the towns Kundah, Coonoor and Gudalur, ii) Vellore with the towns Katpadi & Wallajah, iii) Salem, Dharmapuri & Tiruvannamalai.
	Low-moderate	i) Coimbatore with Mettupalayam, ii) Kanchipuram with Chengalpattu, Sriperumbudur,etc iii) Chennai & iv) Tiruvannamalai with Vandavasi, Cheyyar, etc.
	Low	i) Coimbatore with Vallparai, ii) Tiruvallur with Ponneri, Ambattur, etc.

the areas of maximum seismicity are also the ones that are densely populated. The areas that have the maximum seismic activity are the ones that have a combination of high PGA values, high concentration of lineaments and their intersections, and higher magnitude of earthquakes in the past.

8 Conclusions

This paper has demonstrated that microzonation using remote sensing and GIS is the proper approach to identify seismically active smaller areas within the BIS designated regional categories. Such an exercise will enable planners and disaster managers to prioritize action plan for disaster mitigation and management. Towns and villages with major infrastructure facilities can now be protected in a better way based on this study compared to the possibility of lesser protection that would have been offered based on the existing BIS seismic zonation maps.

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Landslide susceptibility mapping of the Munnar region of southern India using remote sensing and grass GIS

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ABSTRACT

Landslides are one of the natural hazards that affect at least 15% of land area of our country exceeding 0.49 million sq km. Landslides have had disastrous consequences and in 2005, over 500 lives were lost in India due to landslides. Landslides are common in the Himalayas and in the Southern India, especially in the Nilgiris and Kodaikanal hill ranges. Hence adequate attention has to be paid to study these landslides and their causative factors using the field surveys, remote sensing and GIS techniques. In recent decades a remarkable leap forward has been made with these methods because of the diffusion of progressively more efficient and cheaper GISs. The aim of this study is to analyze the factors controlling the landslides in the Munnar region of Southern India and prepare a landslide susceptibility map using Remote Sensing and GRASS GIS as the tools. GRASS GIS (Geographic Resources Analysis Support System) is used in the generation of input layers for the landslide susceptibility mapping. The study area Munnar, extensively known for its tea plantations is a region gaining popularity as a tourist spot. Ecologically and environmentally sensitive, this region, surrounded by vast jungles, has been experiencing landslides recently. This has disturbed the transport and communication routes severely. Even today the risk of yet another landslide remains very high. The monsoon rain brings in its wake many devastating landslides in the region. Though intense and prolonged rainfall can be considered as a triggering factor, the other causes include geological, morphological, physical and human factor. Slope, landuse, vegetation density, anthropogenic elements, availability of unconsolidated sliding material etc. have to be mapped and studied in detail to arrive at an accurate landslide hazard zonation map of this area. This paper aims to study the satellite images, rainfall data and other collateral data of Munnar region and decipher the causative factors that are active in the region for the occurrence of landslides. Proper rank and weights for factors influencing landslides were assigned for each thematic map. Overlay analysis using GRASS GIS software resulted in a map showing the severity of landslide likely to occur, is classified as high, medium and low in the study area. Thus, it is seen that remote sensing and Geographical Resources Analysis Support System are well suited for identifying landslide prone areas.

1 Introduction

1.1 Landslides and their significance

Landslides involves the movement of rock, debris or earth down a slope, and can involve a variety of mechanisms such as falling, toppling, spreading, flowing and sliding. The landslides are often associated with some triggering events like heavy rainfall. P.G.Fookes etal in Engineering Geomorphology states that in 1996 several hundred landslides were triggered by an exceptional landstorm in Washington, USA (over 50 cm in 7 days). The major causes of this disaster results due to various weathering process like physical, chemical and biological. Human interference like the excavation at the toe of the slope results in the cause of devastating landslides. As already said, the study area of Munnar is experiencing major landslides in the recent times. With increasing popularity as tourist destination in the last two decades, wide berths on the hill slopes are cut disturbing the existence of huge granite rocks and trees for the construction of hill resorts. This led to the poor root cohesion in the slopes. A heavy rainfall can act as a triggering factor to induce major landslides during these conditions. The geomorphology, slope, landuse, drainage of Munnar are mapped in detail to arrive at an hazard zonation map.

1.2 Role of remote sensing and GIS in landslide studies

The Landslide Susceptibility Maps identifies the vulnerability of an area to landslide. They form the basis for the landslide hazard assessment. Such maps are prepared with the help of Remote Sensing and GIS. The quality of information obtained from the remote sensing data is high due to the availability of high resolution imageries. Advancement in remote sensing also leads to the availability of high resolution DEMs. Remote sensing techniques act as an standard tool to identify the landslide prone areas by providing data for the derivation of various thematic layers. Thus they help in the prediction of future landslide occurrences, which is very important to those who reside in areas surrounded by unstable slope. The satellite imagery allows a highly accurate investigation of landslide occurrences in the region. Nora Tassetti *et al* (2008) states that the automatic classification of remote sensing images provides many useful land use information to combine in a GIS environment with other spatial factors influencing the occurrence of landslide.In this study the thematic layers such as Slope, Landuse, Drainage, Lineament Occurrence, Lineament Incidence and Landuse are derived from the Remote Sensing data. The ETM () and ASTER data are used for the derivation of the layers. The Slope and Drainage are accurately generated from the ASTER DEM.

A geographic information system (GIS), geographical information system, or geospatial information system is any system that captures, stores, analyzes, manages, and presents data that are linked to location(s). In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology. Nora Tassetti *et al* (2008) states that the advantage of GIS for landslide hazard zonation is due to the possibility of improving models by evaluating their results adjusting the input variables. Users can achieve maximum results by an iterative process of trial and error, whereas it is difficult to use these models even once in the conventional manner. Therefore, more accurate results can be expected. The extraction of the thematic layers and the data processing is done through GIS. The GIS Analysis results in the Landslide Susceptibility Map with the proper ranks and weights.

Open source GIS

The Open Source GIS are those softwares where the source code is accessible to the user. Hence the GIS tool can be customized by the user according to the need of the study. These softwares are cost free and are have several modules for GIS Analysis. This study utilizes the Open Source GIS Software called GRASS GIS. Commonly referred to as GRASS, this is free Geographic Information System (GIS) software used for geospatial data management and analysis, image processing, graphics/maps production, spatial modeling, and visualization. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies. GRASS is an official project of the Open Source Geospatial Foundation. **?** in Open source geographical resources analysis support system (GRASS) for landslide hazard assessment states that the major outcome of this research is the possible use of open source GIS software in the application of landslide hazard assessment. The capability of GRASS in performing such environmental assessment will certainly attract many researchers and organizations with limited budgets, especially in developing countries such as Malaysia. This study on Munnar applies the GRASS GIS for the GIS analysis involved in the preparation of themes from the remote sensing data.

2 Area of study

Munnar is a town located in the Idduki district of India's Kerala state, situated in the Western Ghats of South India (as shown in Figure 1). The name Munnar usually refers to the whole tourist area of the Idukki District of which the town forms only a small part. The study area Munnar, extensively known for its tea plantations is a region gaining popularity as a tourist spot. Ecologically and environmentally sensitive, this region, surrounded by vast jungles, has been experiencing landslides recently. This has disturbed the transport and communication routes severely. Even today the risk of yet another landslide remains very high. There are long cracks visible even in the dry season and there is evidence of seepage flow. Munnar receives an adequate rainfall up to 1800 mm per annum. Inevitably, this monsoon rain brings in its wake many devastating landslides. Though intense and prolonged rainfall can be considered as a triggering factor, the other causes include geological,

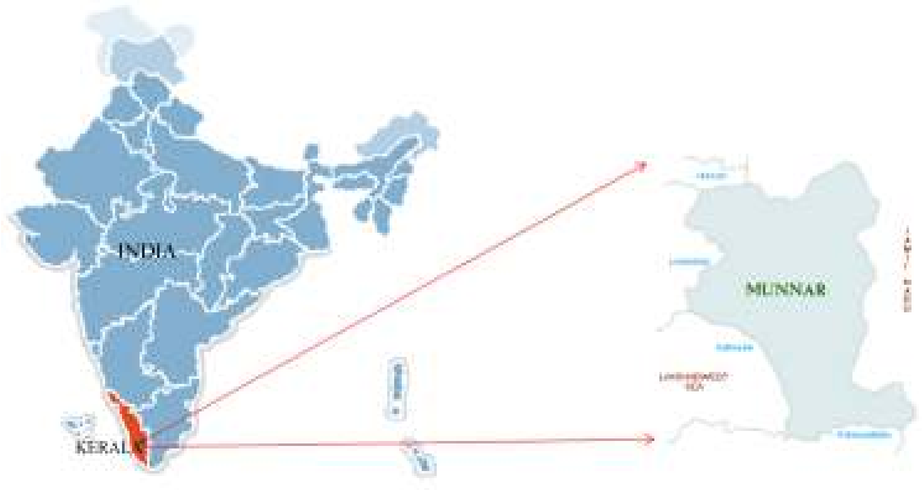

Figure 1. Location map of Munnar.

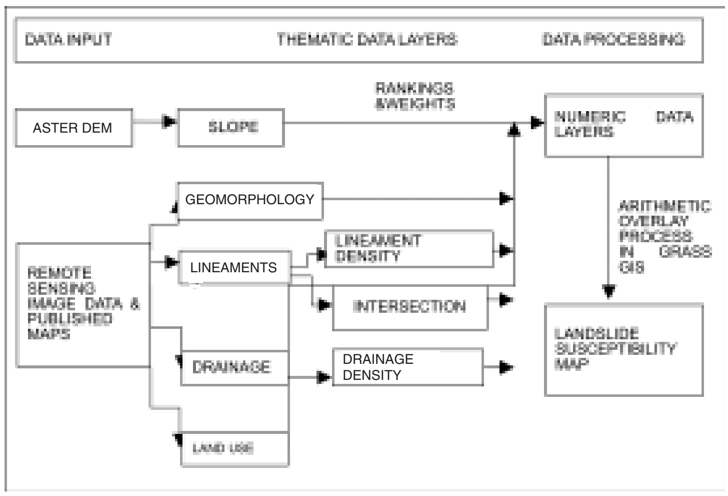

Figure 2. Flowchart of the Methodology adopted.

morphological, physical and human factor. Munnar has been developing into an important tourist destination in the last two decades. Due to this bull dozers cut out wide berths on hill slopes disturbing the existence of huge granite rocks and trees for the sake of hill resorts. This has resulted in poor root cohesion. Thus slope, landuse, vegetation density, anthropogenic elements, availability of unconsolidated sliding material etc. have to be mapped and studied in detail to arrive at an accurate landslide hazard zonation map of this area.

The methodology used for this study is as shown above in Figure 2. Landuse map and lineament maps are prepared from the Landsat ETM satellite imagery by visual interpretation. Digitizing work is carried out in Quantum GIS and the thematic layers are converted into raster maps (after assigning ranks and weights). The slope map, derived from ASTER DEM, is also assigned ranks and weights shown in Table 1. All the thematic maps are converted into world co-ordinate system and overlay analysis is carried out in GRASS GIS. The result is a map showing the landslide prone areas of various categories.

3 Ranks and weights

Geographical problems require the analysis of different factors. For assessing the landslide susceptibility in the study area, various thematic layers like Slope, Geomorphology, Lineament Incidence, Lineament Occurrence, Landuse, and Drainage are considered. Each theme has different importance in the context of determining the susceptible zones. Choudhury (1999) states that the consideration of relative importance factors often leads to a better representation of the actual ground situation. A weight represents the relative importance of a parameter with respect to the objective, The ranks are assigned to each category of the thematic layer. Aparna (2010) states that the determination of weights of each class is the most crucial in integrated analysis as the output is largely dependant on the assignment of the appropriate weight. Hence each thematic layer is assigned a weight based on their influence on the landslide occurrence. The different classes in each theme are assigned a knowledge based ranking. Here the lower rank of 1 indicates poor factor in causing the landslides. While the higher ranks denotes the favorability of the factors in causing the landslides.

Table 1. Table showing ranks and weights assigned to various themes and units

Theme	Weight	Units	Rank	Remarks
Slope	9	0 to 5	1	Steeper slopes are highly prone to landslides. But the slope above are of low susceptibility to the absence of debris over the slope surface.
		5 to 16.3383	2	
		16.3383 to 32.6767	7	
		32.6767 to 49.0150	9	
		49.0150 65.3534	3	
Land use	8	Urban(or) built-up	3	Improper landuse such as fallow land has a higher susceptibility to landslides. Plantation due to the presence of root bindings has lower susceptibility. (Except: Tillages, due to loose soil)
		Current fallow	7	
		Deciduous	4	
		Grassland	4	
		Water body	Masked	
		Scrubland	5	
		Plantation	2	
Geomorphology	8	Reservoir	Masked	Deep pediments are highly susceptible due to the presence of debris. Flood plains are less susceptible as they are on gentle slopes. Valley are less susceptible due to less debris.
		Deep pediments	5	
		Floodplain and Ridges	1	
		Structural hill	3	
		Penni Plain	4	
		Valley	2	
		Denudation hill	1	
Lineament Intersection	7	Nil	0	Presence of increased lineament intersection results in high occurrence of landslides. The lineamnets results in greater weathering of the rocks leading to the loosening of the debris that can slide.
		Low	3	
		Medium	6	
		High	9	
Lineament occurrence	6	Nil	0	Presence of more lineaments results has a higher susceptibility. This lead to weathering of rocks and cause the formation of sliding materials.
		Low	2	
		Medium	4	
		High	8	
Drainage Density	5	Nil	8	When drainage is less, there is more possibility of infiltration, thereby increasing the pore pressure to result in landslides.
		Very Low	6	
		Low	4	
		Medium	2	
		High	1	
		Very High	0	

4 Results and discussions

This study involves the use of remote sensing and GIS for an analysis of the various factors that are responsible for the occurrence of landslides in Ooty area. These factors are discussed in detail as follows.

Landuse:

Landcover is one of the major factors for influencing the occurrence of landslides. Frequently changing the vegetation cover often results in modified landslide behavior. From various investigations it is learnt that landuse/vegetation cover, especially of a woody type with strong and large root system helps to improve the stability of slopes. According to Greenways (1987), vegetation roots penetrate throughout the soils and increase their shear strength. The areas with denser vegetation were considered to be less susceptible to sliding with respect to the area with less or no vegetation. The root system of the vegetation in the forest increases the shear resistance of the mass and through creation of negative pore pressure, increases soil cohesion. Landuse changes in the study area indicate that some activities have taken in the particular area i.e forest land might have been converted in to agriculture or some other landuse. For this task, landuse map is derived from the Landsat ETM image using classification done in GRASS GIS. The landuse map shown in Figure 3 is then verified with the classified maps of Bhoosampada . The landuse map generated is accurate by matching with the Bhoosampada map.

Slope:

Slope constitutes an important parameter in landslide studies, since it forms the basis for the frequency and intensity of landslide. It may be defined as a plane tangent to the surface at any given point and may be measured in degrees or in percentage. Slope gradient has a great influence on the susceptibility of a slope to landsliding. The landslide frequency is generally higher for concave side slopes, and for rock outcrop followed by straight side slopes. As slope increases (except steep slope), the percentage of land affected by landslides may also increase. Storms quickly saturate the topsoil creating landslide hazard on steep slopes that were not stabilized by deep roots or physical barriers. Bare soils, crops

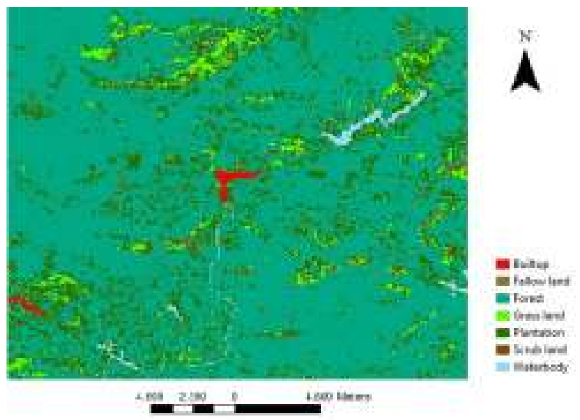

Figure 3. Map showing the landuse of the study area.

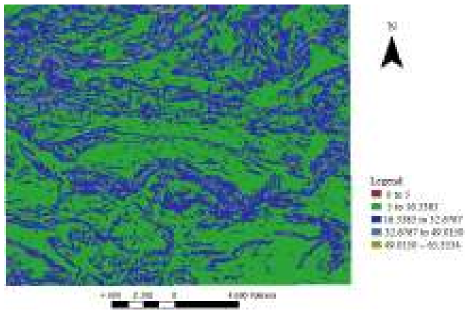

Figure 4. Map showing the slope classification of the study area.

and grass fallow cover types have the highest frequency of landslides as slopes increase. Deep-rooted vegetation that stabilizes the topsoil is a very important factor lowering landslide hazard especially as slopes increase. On steep slopes, landslide hazard is about 13 times greater on bare soil ground than on forest and about five times greater on sites under crop production or grass fallow than on forest Baldiviezo *et al* (2004). The study of Gokceoglu and Aksoy (1996) showed that around Mengen, NW Turkey landslides occurred at locations where slope angles exceed 20°. Dai and Lee (2002) reported that landslide was maximum, when the slope angle between 35° and 40° and it decreases when slope is >40°. In this study, slope angle was derived from the DEM using GRASS GIS and was used as one of the thematic layer for landslide analysis. The slope map of the study area is shown in Figure 4. It is converted into raster to do raster analysis in GRASS GIS. The rank and weight assigned to this layer is given in Table 1.

Drainage:

One of the major influencing elements for the occurrence of landslides in hilly areas is drainage. Drainage frequency describes the degree of topographic dissection of the landscape. Higher drainage density means higher probability of the occurrence of mass failure. As the distance from the drainage line increases, landslide frequency generally decreases. Streams may adversely affect the stability by either eroding the toe or saturating the slope, or both. Terrain modification caused by

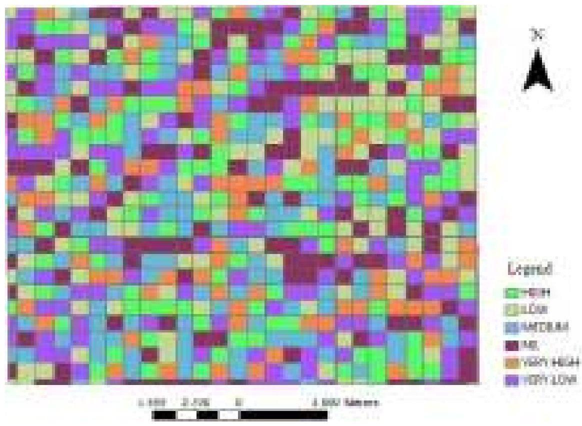

Figure 5. Map showing the drainage occurrence of the study area.

gully erosion may also influence the initiation of landslide.

The drainage map of Munnar region was derived from the DEM in GRASS GIS using inbuilt scripts. The drainage map was overlaid on a grid cover of size 0.50 km × 0.50 km. The number of drainage lines present in each grid is counted which will give the drainage frequency value. Using this frequency value, the drainage frequency map was prepared. The study area has been classified in to 8 types based on the number of drainage incidences. The drainage occurrence in the study area is shown in Figure 5. The rank and weight assigned to this layer is given in Table 1.

Lineament incidence and intersection map:

Lineament represents features such as fracture, joints, faults, bedding, and ridges etc. The influence of these structures is conducive to infiltration and development of hydrostatic pressure on the slope forming material . Faults and landslides have a close association; about 88% of the landslides were detected around Mengen, NW Turkey within an area closer than 250 m to major faults. In the Song river section in India, all the landslides occurred on the escarpment side on the fault scarps, with the formations dipping into the hill. Study of lineaments in the form fractures and beddings are paramount in the analysis of landslide prone areas in the study area. The map was overlaid on a 0.50 km × 0.50 km grid size and the number of lineaments present in each grid was counted which gives the lineament frequency value. The final map was digitized and converted to digital form. An order of importance has been arrived based on the density level of lineaments and ranks are assigned accordingly (Table 1). To study the role of lineament intersection, the lineament map was overlaid manually with a gridded cover of grid size equal to 0.50 km × 0.50 km. The final analog product is then digitized and the value of lineament intersection in each grid is updated in the database in the digital coverage. The presence of lineaments results in the weathering of the surface rocks leading to the formation of abundant sliding materials. With the triggering factor

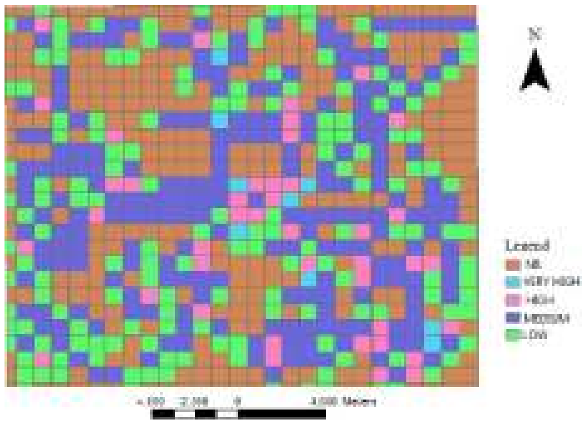

Figure 6. Map showing the lineament incidence of the study area.

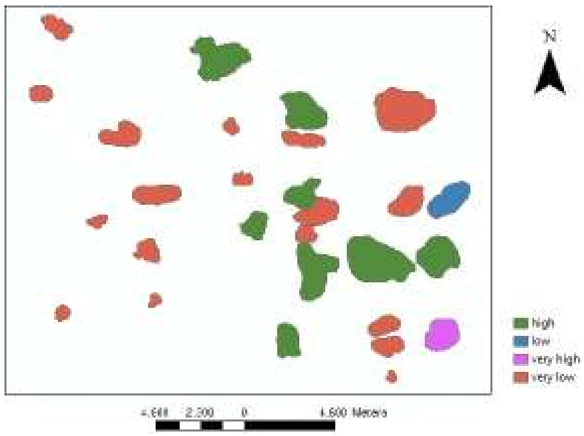

Figure 7. Map showing the lineament incidence of the study area.

like rainfall, these materials slide down causing major landslides. Thus the increased number of lineament intersections results in high occurrence of landslides. Accordingly, a criterion table was generated (Table 1). These maps shown in Figures 6 and 7 are digitized in the Quantum GIS and are converted into raster to do analysis.

Geomorphology:

The geomorphology layer represents the various landforms present in the study area. These landforms will be having a historical background. The Geomorphology layer comprise of the classes like peniplains, shallow pediments, deep pediments, valleys, reservoir, etc. These landforms are interpreted from the ETM imagery and then the vector layer is created in the Quantum GIS. Then the vector layer is converted to raster layer(shown in Figure 8) using the GRASSGIS tools to enable the raster overlay analysis. The suitable ranks and weights based on the influence of the classes over the landslide frequency are assigned as shown in Table 1.

Overlay analysis:

The landslide susceptibility map was prepared in a GRASS GIS environment. Ranks were assigned to each

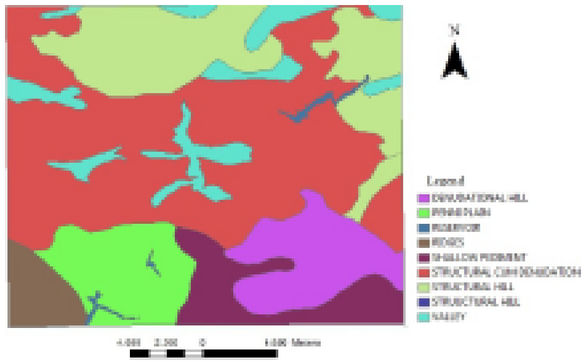

Figure 8. Map showing the geomorphology of the study area.

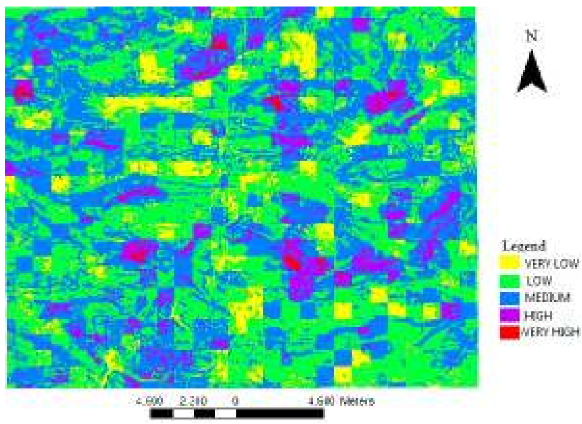

Figure 9. Result of the overlay analysis in GRASS GIS showing the landslide susceptibility zones.

entity in the thematic maps, based on the frequency of occurrences of landslides for a particular theme. Each theme was assigned with a weight depending on the severity of the theme related to landslide occurrences. Overlay analysis was carried out for the raster maps in GRASS GIS. All thematic maps available in digital format were geo-referenced for overlay analysis. Union operation was adopted for overlaying the ranked thematic maps and the final output layer is the Landslide Susceptibility Map. The output map as shown in Figure 9 depicts the susceptibility zones as very high, high, medium, low and very low. The high susceptible zones are found to be on the area with characteristic such as steeper slopes (16.3383–49.0150), deep pediments and barren lands. On the other hand, gentle slopes such as 0–16.3383 possess low landslide susceptible zones.

For validation a detailed study of the landslide occurrence in the Munnar region has been studied. There is good correlation between areas defined as very highly susceptible and the known landslides. There were several landslides recorded previously in the study area and many of them coincided with the very highly to highly susceptible zones. Landslide occurrence in the Maattupatty lake region, Anthoniar colony region, Nallathanni road region coincides with the susceptibility map. Hence, the accuracy of the zonation map can be considered to be appreciable and the logic adopted in assigning ranks and weights to the factors is also correct.

5 Conclusion

The approach used in this study could help to evaluate the current conditions of the landscape and determine, based on simple approaches, the vulnerability of areas to landslides. Variables derived from maps and imagery, such as slope, drainage and landuse can be used to develop hazard assessment tools to predict the spatial distribution of landslides. Landuse, drainage frequency, lineament intersection, lineament occurrence and slope function well as predictors of landslide susceptibility. In the study area, the high and very highly susceptible areas are characterized by non forested areas indicating the influence of vegetation on the initiation of slope instability. The susceptibility maps can potentially be used for assessing landslide hazard in the study area, hence providing a tool for planners and investors from organizations working in the region. The maps would allow planners to allocate resources to areas where conservation practices can most effectively reduce the hazard of landslides. This study also proves the credibility of the Open Source GIS domain to be an effective platform for landslide susceptibility analysis.

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Application of artificial inteligency in disaster mitigation and management

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ABSTRACT

The rapid advance in information processing systems in recent decades directed engineering research towards the development of artificial intelligence (AI) models that can model natural phenomena automatically. In AI models, a process of training is used to build up a model of the particular system, from which it is hoped to deduce responses of the system for situations that have yet to be observed. AI models learn the input output relationship from the data itself. The quantity and quality of the data govern the performance of AI model. This paper will describe the different AI models Artificial Neural Network (ANN) and Least Square Support Vector Machine (LSSVM) for solving different problems in disaster mitigation and management.

1 Introduction

Liquefaction is responsible for large amounts of damage in historical earthquakes around the world. Liquefaction is a phenomenon whereby a granular material transforms from a solid state to a liquefied state as a consequence of increase in pore water pressure. The effective stress of the soil therefore reduces causing loss of bearing capacity. Liquefaction of saturated sandy soils during the past earthquakes has resulted in building settlement and/or severe tilting, sand blows, lateral spreading, ground cracks, landslides, dam and high embankment failures and many other hazards. Damages attributed to the earthquake induced liquefaction phenomenon have cost society hundreds of millions of US dollars (Seed and Idriss, 1982). Therefore, the assessment of the liquefaction potential due to an earthquake at a site is an imperative task in disaster mitigation and management.

The failure of slope (landslide) is frequently responsible for considerable losses of both money and lives, and the severity of the slope problem worsen with increased urban development and change in land use. So, the study of landslide is rapidly becoming the focus of disaster mitigation and management throughout the world. This paper will examine the capability of Artificial Neural Network (ANN) and Least Square Support Vector Machine (LSSVM) for prediction of liquefaction susceptibility and landslide.

2 Details of ANN

It is attempted to implement the ANN backpropgation (BP) methodology in the prediction of liquefaction susceptibility based on the actual SPT field data obtained from Chi–Chi, Taiwan earthquake where liquefaction and no liquefaction was observed. This has been done by developing two models (MODEL I and MODEL II). This study uses the database collected by Hwang and Yang (2001). Out of total 288 datasets, a total of 164 data are for the sites those liquefied and 124 are for non-liquefied sites after earthquake. The liquefaction susceptibility of a soil mass during an earthquake is dependent on both seismic and soil parameters. So, in MODEL I, the input parameters are corrected SPT value $[(N_1)_{60}]$ and cyclic shear stress ratio (CSR). To use these data for classification purpose, a value of -1 is assigned to the liquefied sites while a value of $+1$ is assigned to the non-liquefied sites so as to make this a two-class classification problem. So, the output of the model will be either 1 or -1. The data is normalized against their maximum values (Sincero, 2003). In carrying out the formulation, the data has been divided into two sub-sets: such as

(a) A training dataset: This is required to construct the model. In this study, 202 data out of the 288 are considered for training dataset.

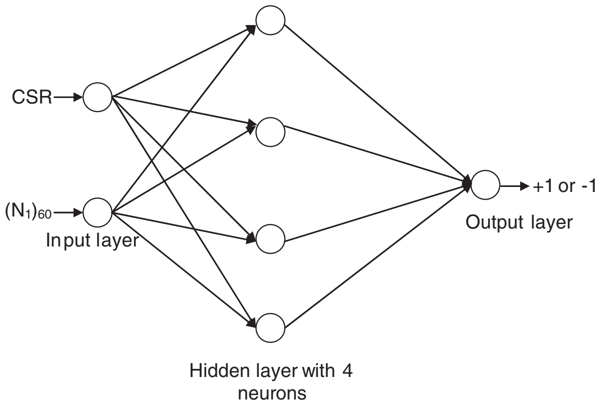

Figure 1. ANN architecture adopted for MODEL I.

(b) A testing dataset: This is required to estimate the model performance. In this study, the remaining 86 data is considered as testing dataset.

In MODEL II, the input variables are $(N_1)_{60}$ and PGA. In MODEL II, the same training dataset, testing dataset and normalization technique have been used similar to MODEL I. MODEL II has also been verified using additional 85 case histories (which were not part of either training or testing dataset) available globally as presented by Goh (1994). This global data set consists of a total of 85 records of 13 earthquakes that occurred in different countries during the period of 1891–1980. Both MODEL I and MODEL II have been constructed using neural network tool box in MATLAB (Demuth and Beale, 1999).

For predicting liquefaction susceptibility, in MODEL I, the two input variables (CSR and $(N_1)_{60}$) are used with BP model. Hence, the input layer has two neurons. The only output is the class +1 or −1 and therefore the output layer has only one neuron. The optimum backpropagation network that is obtained in the present study is a three-layer feed forward network. Figure 1 shows the final architecture of the BP model with one hidden layer.

In this study, the transfer function used for the hidden layer is logsig. The tansig transfer function has been used for the output layer. The number of neurons in the hidden layer is determined by training several networks with different numbers of hidden neurons and comparing the predicted results with the desired output. Using too few hidden neurons could result in huge training errors and errors during testing, due to underfitting and high statistical bias. On the other hand, using too many hidden neurons might give low training errors but could still have high testing errors due to overfitting and high variance. In this study, hidden layer with 4 neurons has been used as shown in Figure 1. For BP model, the results have been achieved at 382 epochs (an epoch is one complete presentation of the entire set of training pattern during the training process). The value of mean square error (MSE) for the BP model has been computed and monitored during training. Figure 2 shows how the

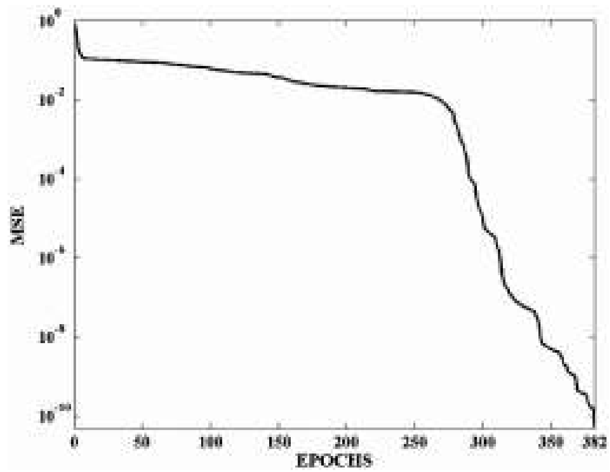

Figure 2. MSE versus epochs with BP model for MODEL I.

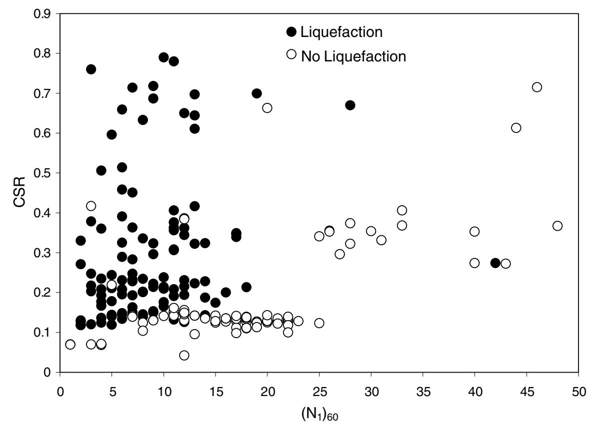

Figure 3. Plot between CSR and $(N_1)_{60}$ for MODEL I using training dataset for BP model. training and testing dataset respectively. Results indicate that BP model can be used as a practical tool for the determination of liquefaction susceptibility of soil.

MSE for the model reduces as training proceeds. Training and testing performance are calculated by using the following formula:

$$\text{Training/Testing performance (\%)} = \left(\frac{\text{No of data predicted accurately by ANN}}{\text{Total data}}\right) \times 100. \quad (1)$$

The performance of training data is 95%. According to the results of network training, the network has successfully captured the relationship between the input parameters and output. In order to evaluate the capability of the BP model, the model is validated with new data that are not part of the training dataset. In this case, the performance of BP model is 88%. Figures 3 and 4 illustrate the plot between CSR and $(N_1)_{60}$ for training and testing dataset respectively. Results indicate that BP model can be used as a practical tool for the determination of liquefaction susceptibility of soil.

In MODEL II, the input variables are PGA instead of CSR and $(N_1)_{60}$. So, input layer has only two neurons. The output of the model is a liquefaction classifier +1 or

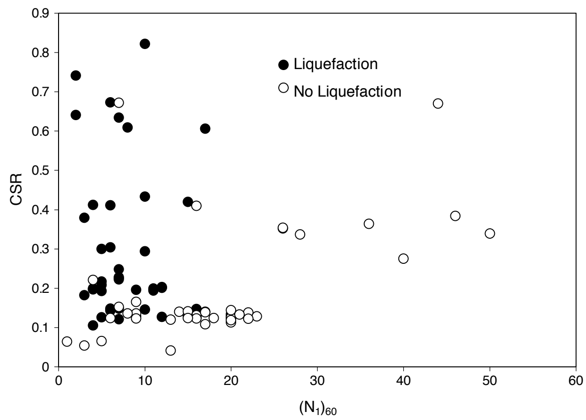

Figure 4. Plot between CSR and $(N_1)_{60}$ for MODEL I using testing dataset for BP model. In MODEL II, the input variables are PGA instead of CSR and $(N_1)_{60}$. So, input layer has only two neurons. The output of the model is a liquefaction classifier +1 or −1. Hence output layer has only one neuron. MODEL II uses three layer feed forward network with 5 neurons in hidden layer and it has been shown in Figure 5. In this study, the transfer function used in hidden layer is logsig. The tansig transfer function has been used in the output layer.

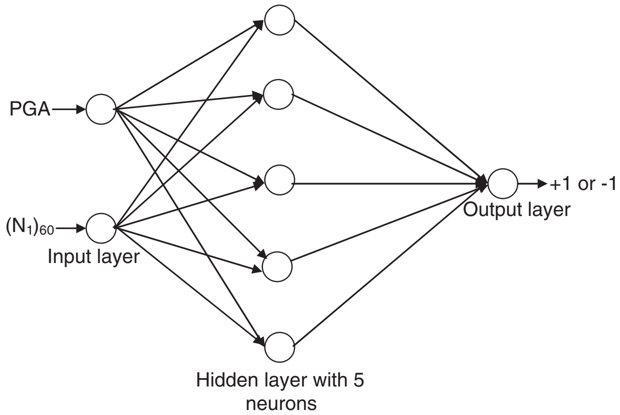

Figure 5. ANN architecture adopted for MODEL II.

−1. Hence output layer has only one neuron. MODEL II uses three layer feed forward network with 5 neurons in hidden layer and it has been shown in Figure 5. In this study, the transfer function used in hidden layer is logsig. The tansig transfer function has been used in the output layer.

The variation of MSE with epochs has been shown in Figure 6. For MODEL II, the results are converged corresponding to 295 epochs (see Figure 6). The performance of training and testing dataset is 94% and 87% respectively. So, there is a marginal reduction of performance of MODEL II compare to MODEL I. Figures 7 and 8 demonstrate the plot between PGA and $(N_1)_{60}$ for training and testing dataset respectively. For the global data, the performance of BP model with PGA and $(N_1)_{60}$ is 70.58%. Figure 9 depicts the plot between PGA and $(N_1)_{60}$ for global data using BP model.

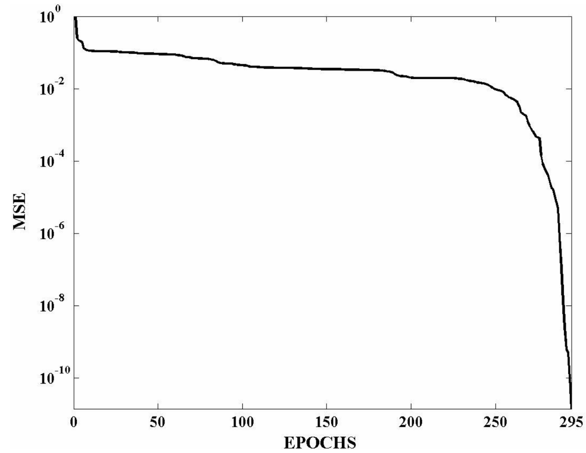

Figure 6. MSE versus epochs with BP model for MODEL II.

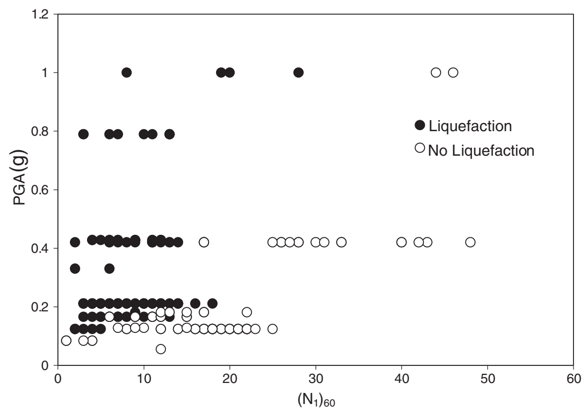

Figure 7. Plot between PGA and $(N_1)_{60}$ for MODEL II using training dataset for BP model.

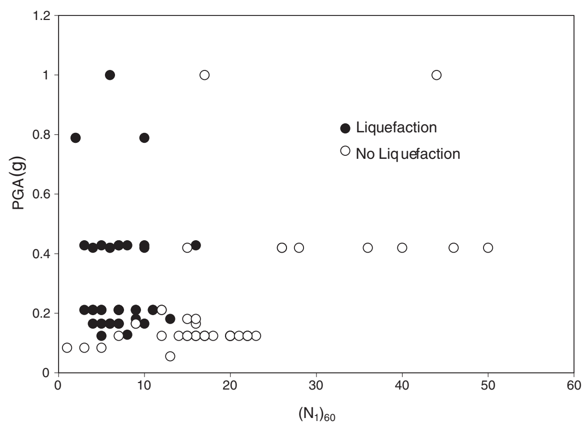

Figure 8. Plot between PGA and $(N_1)_{60}$ for MODEL II using testing dataset for BP model.

3 Details of LSSVM

In the present study, LSSVM has been used for prediction of the status (S) of rock slope. The data has been taken from the work of Sakellatiou and Ferentinou (2005). The dataset consists of 22 case studies of rock slopes. To use these data for classification purpose, a value of 1 is assigned to the stable condition of rock slope while a value -1 is assigned to the failure condition of rock slope so as to make this a two-class classification problem. A binary classification problem is considered having a set of training vectors (D) belonging to two separate classes.

$$D = \{(x^1, y^1), \ldots, (x^1, y^1)\} \qquad x \in R^n, y \in \{-1, +1\} \tag{2}$$

where $x \in R^n$ is an n-dimensional data vector with each sample belonging to either of two classes labelled as $y \in \{-1, +1\}$ and l is the number of training data. The stability of rock slope depends on unit weight (g), cohesions (c_A) and (c_B), angles of internal friction (f_A) and f_B, angle of the line of intersection of the two joint-sets (y_p), slope angle (y_f) and height (H), where A and B refer to the two joint sets $x = \left[\gamma, c_A, c_{B,} \phi_A, \phi_B, \psi_p, \psi_f, H\right]$. In the current context of classifying the status of rock slope, the two classes labeled as (+1, −1) may mean stable rock slope and failed rock slope. The SVM approach aims at constructing a classifier of the form (Suykens *et al*, 1999, 2002):

$$y(x) = sign\left[\sum_{k=1}^{N} \alpha_k y_k \psi(x, x_k) + b\right] \tag{3}$$

where α_k are positive real constants, b is a real constant and $\psi(x, x_k)$ is kernel function. For the case of two classes, one assumes

$$\begin{aligned} &w^T \varphi(x_k) + b \geq 1, \text{ if } y_k = +1 \text{ (Stable rock slope)} \\ &w^T \varphi(x_k) + b \leq 1, \text{ if } y_k = -1 \text{ (Failed rock slope)} \end{aligned} \tag{4}$$

which is equivalent to

$$y_k\left[w^T \varphi(x_k) + b\right] \geq 1, \qquad k = 1, \ldots, N \tag{5}$$

where $\varphi(\cdot)$ is a nonlinear function which maps the input space into a higher dimensional space. According to the structural risk minimization principle, the risk bound is minimized by formulating the following optimization problem:

$$\begin{aligned} &\text{Minimize: } \frac{1}{2} w^T w + \frac{\gamma}{2} \sum_{k=1}^{1} e_k^2 \\ &\text{Subjected to: } y_k\left[w^T \varphi(x_k) + b\right] = 1 - e_k, \\ &k = 1, \ldots, N \end{aligned} \tag{6}$$

where, g is the regularization parameter, determining the trade-off between the fitting error minimization and smoothness and e_k is error variable.

In order to solve the above optimization problem Equation (6), the Lagrangian is constructed as follows:

$$\begin{aligned} L(w, b, e, \alpha) = &\frac{1}{2} w^T w + \frac{\gamma}{2} \sum_{k=1}^{1} e_k^2 \\ &- \sum_{k=1}^{N} \alpha_k \left\{ y_k \left[w^T \varphi(x_k) + b\right] - 1 + e_k \right\} \end{aligned} \tag{7}$$

where α_k are Lagrange multipliers, which can be either positive or negative due to the equality constraints

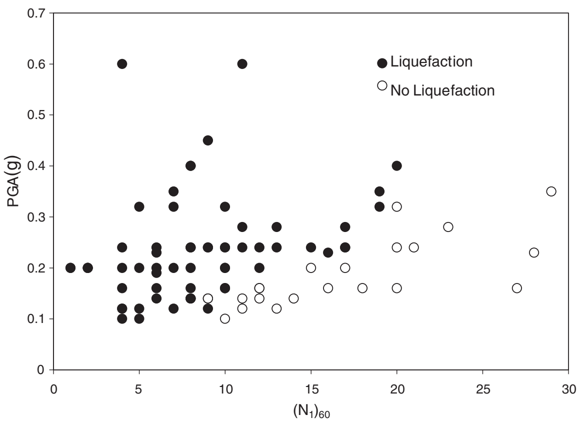

Figure 9. Plot between PGA and $(N_1)_{60}$ for global data for BP model.

as follows from the Kuhn–Tucker conditions (Fletcher, 1987). The solution to the constrained optimization problem is determined by the saddle point of the Lagrangian function $L(w, b, e, a)$, which has to be minimized with respect to w, b, e_k and α_k. Thus, differentiating L (w, b, e, α) with respect to w, b, e_k and α_k and setting the results equal to zero, the following three conditions have been obtained:

$$\begin{aligned} &\frac{\partial L}{\partial w} = 0 \Rightarrow w = \sum_{k=1}^{N} \alpha_k y_k \varphi(x_k) \\ &\frac{\partial L}{\partial b} = 0 \Rightarrow \sum_{k=1}^{N} \alpha_k y_k = 0 \\ &\frac{\partial L}{\partial e_k} = 0 \Rightarrow \alpha_k = \gamma e_k \\ &\frac{\partial L}{\partial \alpha_k} = 0 \Rightarrow y_k\left[w^T \varphi(x_k) + b\right] - 1 + e_k = 0, \\ &k = 1, \ldots, N. \end{aligned} \tag{8}$$

The above equitation (8) can be written immediately as the solution to the following set of linear equations (Fletcher, 1987)

$$\begin{bmatrix} I & 0 & 0 & -Z^T \\ 0 & 0 & 0 & -Y^T \\ 0 & 0 & \gamma I & -I \\ Z & Y & I & 0 \end{bmatrix} \begin{bmatrix} w \\ b \\ e \\ \alpha \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \tag{9}$$

where $Z = [\varphi(x_1)^T y_1; \ldots; \varphi(x_N)^T y_N]$, $Y = [y_1; \ldots; y_N]$, $I = [1; \ldots; 1]$, $e = [e_1; \ldots; e_N]$, $\alpha = [\alpha_1; \ldots; \alpha_N]$.

The solution is given by

$$\begin{bmatrix} 0 & -Y^T \\ Y & \Omega + \gamma^{-1} I \end{bmatrix} \begin{bmatrix} b \\ \alpha \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \tag{10}$$

where $\Omega = Z^T Z$ and the kernel trick can be applied within the Ω matrix.

$$\begin{aligned} \Omega_{kl} &= y_k y_l \varphi(x_k)^T \varphi(x_l) \\ &= y_k y_l K(x_k, x_l), \quad k, l = 1, \ldots, N. \end{aligned} \tag{11}$$

The classifier in the dual space takes the form

$$y(x) = sign\left[\sum_{k=1}^{N} \alpha_k y_k K(x, x_k) + b\right] \tag{12}$$

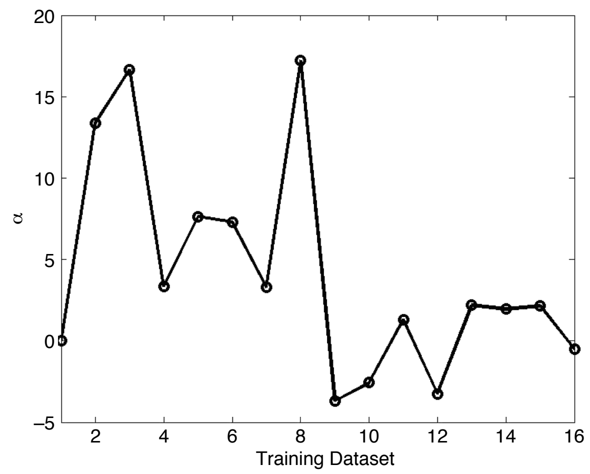

Figure 10. Values of α.

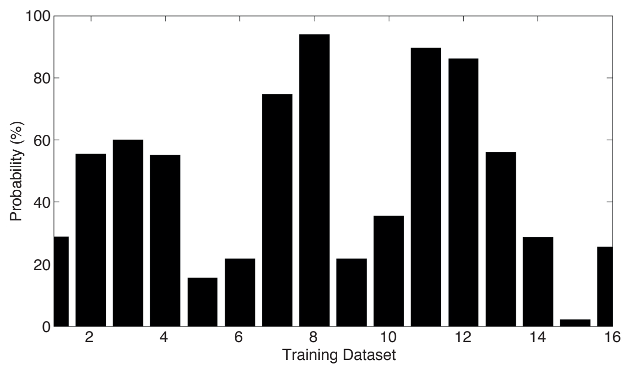

Figure 11. Probability of training dataset.

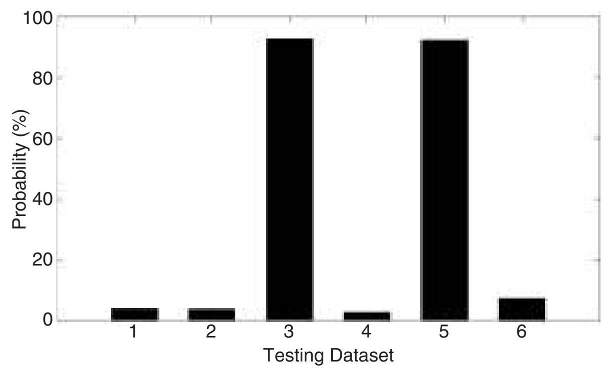

Figure 12. Probability of testing dataset.

where sign $(\cdot)$ is the signum function. It gives $+1$ (stable rock slope) if the element is greater than or equal to zero and -1 (failed rock slope) if it is less than zero.

In carrying out the formulation, the data has been divided into two sub-sets: such as

(a) A training dataset: This is required to construct the model. In this study, 16 out of the 22 data are considered for training dataset.

(b) A testing dataset: This is required to estimate the model performance. In this study, the remaining 6 data is considered as testing dataset. To train the LSSVM model, radial basis function has been used as kernel function. The data are normalized between 0 to 1. The program is constructed using MATLAB.

The optimum value of g and width of radial basis function(s) has been determined trial and error approach during training process. Different combinations of g and s values are tried to yield the best performance on training data for LSSVM model. The design value of g and s is 100 and 22 respectively. Training and testing performance have been calculated from the following formula

$$\text{Training/Testing performance } (\%) = \left(\frac{\text{No data predicted accurately by LSSVM}}{\text{Total data}} \right) \times 100 \quad (13)$$

Radial basis function gives a performance of 100%, with no errors in the training patterns and no error in testing patterns. So, the performance of training and testing is same. LSSVM has the ability

Tables 1 and 2 shows the performance of training and testing data respectively. The following equation is developed for the prediction of status of slope(by putting the value of $s = 22$, $b = 0.598$ in equation (14).

The value of α_i is given in Figure 10.

Probability has been also calculated for training and testing dataset (see Figures 11 and 12). For prediction of stability of slope, the determination of probability is important in order to estimate the corresponding risk. In ANN, probability is obtained using a local quadratic approximation to the nonconvex cost function. But, no approximation has to be made for LSSVM since a quadratic cost function is used.

The determination of stability of rock slope is a complex problem in rock mechanics. For most mathematical models that attempt to solve this problem, the lack of physical understanding is usually supplemented by either simplifying the problem or incorporating several assumptions into the models. In contrast, as shown in this study, LSSVM uses the data alone to determine the parameters of the model. In this case, there is no need to simplify the problem or to incorporate any assumptions. Moreover, LSSVM can always be updated to obtain better results by presenting new training examples as new data become available.

4 Conclusion

This paper successfully applied ANN and LSSVM for prediction of liquefaction susceptibility and status of rock slope respectively. The performance is encouraging for both cases. User can use the developed equation for practical purpose. In the development of the ANN and LSSVM models discussed here, significant effort is required to build the machine architecture. However, once developed and trained, the transpired ANN and LSSVM models performed the simulation in a small fraction of the time required by the physically based model. Moreover, ANN and LSSVM can always be updated to obtain better results by presenting new training examples as new data become available. In summary, it can be concluded that AI techniques can be applied for solving different problems in disaster mitigation and management.

Table 1. Performance of training dataset.

d **(kN/m^3)**	c_A **(kPa)**	c_B **(kPa)**	f_A(°)	f_B(°)	y_p(°)	y_f (°)	$H(m)$	**Actual class**	**Predicted class**
25.14	23.94	47.88	20	30	31.2	65	30.5	1	1
25	14.36	16.76	28	18	30	45	37	−1	−1
22.8	0	0	35	35	38	47	110	−1	−1
26	0	0	30.6	22.8	30.6	33	270	1	1
26	20	20	27	27	60	70	44	1	1
26	0	0	39	39	60	70	44	−1	−1
26.66	0	0	45	45	35	50	150	1	1
25	0	0	32.4	32.4	30	48	50	1	1
18.84	0	0	30	30	37.5	45	61	−1	−1
23.24	19.15	28.73	22.6	19.1	29	40	46	−1	−1
27	0	0	30	30	37.5	26	110	1	1
27	0	0	20	30	37.5	26	110	1	1
27	0	0	20	30	43	26	50	1	1
27	20	20	20	30	43	26	60	1	1
27	0	0	10	10	43	26	60	−1	−1
24	49	49	20	30	65	31	40	1	1

Table 2. Performance of testing dataset.

d **(kN/m^3)**	c_A **(kPa)**	c_B **(kPa)**	f_A (°)	f_B(°)	y_p(°)	y_f (°)	$H(m)$	**Actual class**	**Predicted class**
20	0	0	40	4	45	60	100	−1	−1
19.9	40	19	22	22	37	42	140	−1	−1
26.66	0	0	35	35	30	42	150	1	1
18.84	30.07	3.6	30	36.7	37.5	45	61	−1	−1
27	0	0	20	30	37.5	26	50	1	1
27	0	0	15	15	43	26	60	−1	−1

$$s = sign\left[\sum_{i=1}^{16}\alpha_i y_i \exp\left[\frac{-\left\{\left(d, c_A, c_B, \phi_A, \phi_B, \psi_p, \psi_f, H\right)_i - \left(d, c_A, c_B, \phi_A, \phi_B, \psi_p, \psi_f, H\right)\right\} * \left\{\left(d, c_A, c_B, \phi_A, \phi_B, \psi_p, \psi_f, H\right)_i - \left(d, c_A, c_B, \phi_A, \phi_B, \psi_p, \psi_f, H\right)\right\}^T}{968}\right] + 0.5981\right] \tag{14}$$

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The trilemma of soil carbon degradation, climate change and food insecurity

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ABSTRACT

The carbon dioxide (CO_2) concentration in the atmosphere is increasing at an alarming rate especially due to anthropogenic reasons. This increased concentration causes climate change issues and related problems like food insecurity and ecosystem degradation. At this point it is important to device ways and means to trap the excess CO_2 in the atmosphere. Soil carbon sequestration is a viable option to tackle these uncertainties. The potential of different soil to sequester carbon in the form of soil organic carbon (SOC) differs and their SOC accrual value is an indicator of its sink capacity to trap atmospheric carbon. The study forms a baseline assessment towards the consideration of the different soils as promising sinks for offsetting atmospheric CO_2. The application of biochar as a green viable option to increase SOC is an emerging research field in this aspect. Amendment of biochar as a soil conditioner it growth trials shows its potential in increasing SOC pool and reducing soil emission especially CO_2. In this paper a scientific approach has been taken up to relate SOC and food security from a climate change view point.

1 Introduction

The technical potential of Carbon (C) sequestration in our soils help in mitigating climate change and thus describes its positive impacts on agronomic productivity and global food security. C concentration in the atmosphere is increasing at the rate of about 4 billion (2 parts per million) per year, mainly from fossil fuel burning, biotic and soil pools. This will result in the decline of ecosystem services especially of terrestrial systems and also further leads to global warming issues and thus a double jeopardy. As the vexing problems of climate change issues and food insecurity stems from the increased concentration of carbon dioxide in the atmosphere, it is necessary to trap this excess carbon dioxide in a safe long lived storage and this process is called carbon sequestration. Soil C sequestration involves adding the maximum amount of carbon possible to the soils. Through this it is possible to convert degraded soils into restorative land and adopting recommended management practices (RMP) which can increase soil carbon pool. Devising site specific technologies appropriate for different soils is the major step to create a positive soil C budget through which optimum production potential and climate change mitigation can be achieved. Yield or production optimization is a critical factor which has a direct correlation with soil organic carbon pool. Data on scientific studies reveal the positive interaction between SOC concentration and yield optimization for diverse soils all around the world. Studies in alluvial soil of New Delhi portrayed a sharp increase in the yield of grain and biomass of cowpea (1.6 Mg/ha), for Maize (7.9 Ma/ha) and for wheat (12.7 Ma/ha) with an increase in SOC concentration of about 1 % in the root zone. Increased grain yield by 0.174 Mg/ha for wheat (*Triticun aestivum* L) and 0.235 Mg/ha for rice (*Oriza sativa* L.) is observed from the soils of Central India with an increase in the SOC pool by 1 mg/ha. Field trials in W. Africa indicated that 1% increase in SOC concentration increased yield of upland rice by 0.31 Mg/ha while Podozolic loamy soils of Russia, showcased a rise in the yield of wheat by 0.33 Mg/ha and that of barley (*Hordeum vulgare* L) by about 0.29 Mg/ha. Increase in the SOC concentration in the root zone by 1 Mg/ha could increase production of food grain in developing countries by 32 million Mg/yr (Lal R., 2009).

Table 1. SOC of various land use category.

Ecosystem type	SOC concentration (%)
Paddy field	4.3
Mixed land	3.8
Plantation land	2.7
Forest	5.5

Table 2. PCM concentrations of different soil samples.

Ecosystem type	PCM concentration ($mg/CO_2/m^2/h$)
Paddy field	13.7
Mixed land	12.4
Plantation land	13.3
Forest	12.0

The importance of carbon sequestration in soil and vegetation pool is more when compared to other type of sequestration due to its cost effectiveness and also the ecosystem services it provides. The cost of carbon sequestration and storage technology is high and beyond affordable for most of the developing and under developed countries where we can recommend soil and vegetation carbon sequestration as it is a low cost or negative cost process, considering the agronomic production and ecosystem services. The dynamics of soil carbon sequestration process must be evaluated in the context of local soil and vegetation attributes with its pool or sink capacity and spatial variability. The role of traditional knowledge and its application towards achieving the maximum C sequestration in soil and vegetation without compensating yield optimisation should be addressed with due importance. The application of 'Biochar' - the black carbon derived from biomass is a novel idea to achieve soil carbon sequestration and productivity.

As most agricultural soils are severely depleted of their OC pool they are highly prone to degradation, biodiversity decline and quality deterioration. Productive land employed under plantation activities show sharp decline in SOC concentration, high mineralization and low production potential which adds pressure to the existing problems of climate change and food insecurity. It is high time to devise a sustainable and tradition based technology to restore the SOC pool to escape from the vagaries of climate change, food insecurity and soil degradation. Application of biochar is one such option, the biomass derived charcoal under high temperature treatment in anoxic condition is one of the age old traditional practice, employed to augment production through conditioning soil properties especially SOC pool. Several researches revealed the speciality of biochar as a carbon negation way to sequester C in soil along with the promise of sufficient food security.

The work has been taken up to appraise the SOC pool of selected soil samples under different land use categories in order to assess its sink or source strength. Under growth trials, application of biochar as a green viable option to increase soil SOC concentration and yield optimisation from a climate change perspective has been taken up.

2 Methedology

Selected pockets in various land use categories of Kottayam district, Kerala has been selected for the study. Measurement methods of SOC pool is done as per the methods prescribed by IPCC (2006). Potential carbon Mineralisation (PCM) is determined through the modified incubation method described by Haney *et al.* (2004).

Regarding experimentation part, biochar derived from dried rubber shells pyrolysed at a temperature of 450–500 degree C in muffle furnace were used to conduct the growth trials with Amaranths seedlings and a preferable Rice cultivar (*Oriza Sativa* L) of D1 variety.

In pot trials, Biochar at different concentration like 20, 40, and 60 gm per were amended per Kg soil and combination of 20 gm biochar: 20 gm vermicast was also tried. Controls were also set with no amendments and vermicast amended pots. Pot trial with D1 rice (*Oriza Sativa* L) variety was conducted to demonstrate the soil/vegetation carbon sequestration potential and yield optimization through biochar application. Organic farming techniques with traditional knowledge application were emphasised in the trials. Results were drawn mainly for SOC concentration, vegetation/biomass carbon, yield in terms of grain quality and quantity, detailed growth profile etc.

3 Result and discussion

3.1 Soil organic carbon pool

The study showed a considerable variation in the SOC concentration and sequestration potential among the soil samples of different ecosystem. Soil of forest system recorded maximum SOC concentration of 5.5% compared to all other samples.

The SOC sequestration potential ranges in the order: Forest>Paddy>Plantation>Mixed. In paddy soil, the SOC pool strength was comparatively higher (4.3%) than that of mixed (3.8%) and plantation (2.7%) soils. The SOC pool strength bears a direct correlation with the intensity of land use activities or disturbances to which the soil is subjected to.

The capacity of forest soil in sequestrating considerable amount of SOC can be attributed to the intactness of the system and also due to high litter input and subsequent decomposition processes. However, irrespective of the intensive management activities, paddy soil showed an inmate capacity to store enormous quantity of SOC. Study showed that in wetland soil the rate of carbon sequestration will be more and is above the emission avoidance rate because of the decomposition of cultivated peat. Soil from plantation and mixed system showed less C pool strength due to continuous disturbance, interms of land clearance, manuaring and fertiliser application.

Table 3. Plant growth response towards biochar application.

Trials	Shoot length (cm)	Number of leaves	Mean leaf area (cm^2)
Control	4	5	1.19
Soil + 20 gm B	4.8	5	1.28
Soil + 40 gm B	7.3	6	3.1
Soil + 60 gm B	11.5	7	9.63
Soil + 20 gm B + 20 gm v	13.8	8	10.5
Soil + 40 gm v	8.6	7	4.28

* B - biochar, V - Vermicast

3.2 Potential carbon mineralization (PCM)

PCM is one of the soil carbon cycling parameter and it is an active soil carbon fraction that change rapidly with time and reflect changes in soil quality and productivity.

Potential Carbon Mineralisation (PCM) values are recorded high for paddy and plantation soil which can be attributed to continuous disturbance in the soil column in terms of management activities. The least value is recoded from the forest soil (12.3 mg/CO_2/m^2/h) due to the undisturbed condition of the soil column. From an overall view the PCM values ranges in the order: Paddy>Plantation>Mixed>Forest. As the soil degradation increases the rate of PCM also increases and hence an augmented level of CO_2 in the atmosphere can be expected.

3.3 Soil carbon pool and ecosystem services

SOC concentration in an optimal range promotes agronomic yield of crops and other processes like soil structuring , preventing soil erosion, elevate water holding capacity, aggregate stability, plant growth profile etc. Soil of forest ecosystem was noted for its high SOC content and low mineralization rate (12.32 mg/CO_2/m^2/h). This system can be better termed as a carbon sink and the benefit of holding such a vast sink of carbon accrual in the soil can be viewed from the tangible and intangible goods and services provide by the system as a whole. In the forest ecosystem, the erosion activities and soil degradation rate were found to be less and the presence of rich soil biota represented the system functioning efficiency. In terms of ecosystem functioning and resilience benefit this pool strength plays a major role. This is a natural C sequestration process in the vegetation/biomass and in soil and is also cost-effective and has numerous co-benefits. Likewise the soils of wetland regions also locked immense amount of SOC and the benefits were recorded in terms of plant growth, associated faunal population, soil intactness, vigour and productivity. Here, particularly in this case, the agronomic productivity in terms of rice yield cannot be achieved without an optimal SOC concentration in the root zones of rice plant, for which SOC sequestration is an essential prerequisite. On contrary to this, soils of plantation and mixed land category were unable to support a rich soil biota and other soil quality parameters since the SOC concentration was considerably low. The economic potential behind this venture will be high as most soils have a technical potential of sink capacity of 20 to 50 mt of carbon per hectare that can be sequestered over a 20 to 50 year time span.

3.4 Crop yield response to SOC accural capacity under biochar application

Agronomic response of crops to SOC concentration depends on numerous factors. This experiment was specifically conducted to establish the relationship between SOC concentration and agronomic yield.

3.5 Impact of biochar on growth profile and soil parameters of Amaranths plants

The application of biochar in different concentration as trials influenced the growth profile of Amaranths plants and also the soil properties like SOC and PCM concentration.

3.5.1 Growth response

Growth profile of the plants treated with different concentrations of biochar showed notable differences, (Table 3). Plant growth response towards biochar application was recorded in terms of shoot length, number of leaves and Mean leaf area (cm^2).

Visual assessment of the trials revealed that the biochar with equal proportion of Vermicast (20:20 gm) amended plant demonstrated healthy growth trends (13.8 cm shoot length, 8 leaves with 10.5 cm^2 mean leaf area) which is followed by the trial with highest concentration of biochar (60 gm).

3.5.2 Soil response

The soils subjected to different concentration of biochar showed variations in the parameters under consideration and the results are given in Table 4.

The SOC values ranged between 1.36 - 3.67% in the trials, with 0.6% in control. The soil amended with equal proportion of biochar and vermicast showed the highest value (3.67%) followed by the trial with maximum (60 g) amount of biochar (3.16%). The trials with 40 gm biochar and 40 gm vermicast also showed similar results (2.7 %). The PCM value was found to be low in the soil amended with equal proportion of Biochar and vermicast. The C/N value was high in biochar + vermicast amended soil.

Table 4. Soil responses towards biochar application.

Conditions	SOC (%)	Soil respiration ($mgCO_2/m^2/hr$)	C/N ratio (%)
Control	0.6	5.302	1.43
Soil + 20 gm B	1.363	44.23	4.87
Soil + 40 gm B	2.712	33.74	7.45
Soil + 60 gm B	3.19	77	8.76
Soil + 20 gm B + 20 gm v	3.67	10.49	10.08
Soil + 40 gm v	2.712	15.311	6.46

* B - biochar, V - Vermicast

Table 5. Growth responses under different amendments.

Condition	Carbon Content (g)			Grain weight (g)
	Root	Shoot	Total	
Sulphate	1.51	2.64	4.15	2.9
Urea	1.25	1.54	2.79	1.6
B - 20 g	0.95	0.71	1.66	1.6
B - 60 g	1.05	1.01	2.06	1.07
Cow dung	0.49	1.175	1.67	2.4
Biochar + Cow dung	3.7	3.25	6.95	3
No Treatment	0.45	1.37	1.83	2.7

Table 6. Soil response under different amendment conditions.

Condition	SOC content ($g\ C\ g^{-1}$)	PCM Content ($g/CO_2/m^2/h$)
Sulphate	0.133	0.35
Urea	0.130	0.42
B − 20 g	0.135	0.32
B − 60 g	0.139	0.37
Common Cow dung	0.138	0.43
Biochar + Cow dung	0.140	0.35
No Treatment	0.133	0.34

3.6 Impact of biochar on growth profile and soil parameters of D1 rice cultivar

Application of biochar in different concentration and in combination with cow dung produced profound changes in the growth profile and soil parameters

3.6.1 Growth response

Growth profile of rice cultivar treated with different concentrations of biochar and also with chemical amendments like sulphate and urea showed notable differences and the results are as per the table 5.

The biomass allocation recorded maximum for the Biochar + cow dung combination (6.95 gm). The grain weight was found to be maximum (3 gm) under the effect of this preferred combination. The tiller number recorded maximum with healthy growth trends in terms of grain yield and size. All other amendments produced minimum biomass carbon and grain yield.

3.6.2 Soil response

Growth trials with D1 rice cultivar using different chemical amendments and biochar combination showed a notable response in the soil parameters like SOC and PCM.

The study revealed that, the application of biochar alone and in combination with cow dung increased the SOC concentration in the soils of root zone compared to the control and that of fertilizer amended soils. Amendment of Biochar with cow dung combination showed the highest SOC concentration (0.140 g C g^{-1}). The PCM under this combination recoded 35 ($g/CO_2/m^2/h$) which showed a slight variation from the control. The study supports Biochar + cow dung as a preferred combination on a sustainable production system without compromising with soil organic carbon loss. The growth trials revealed that biochar is a sustainable carbon negation option and can address the problem of food insecurity, soil carbon loss and climate change.

4 Conclusion

Soil carbon sequestration is a win- win strategy. Carbon sequestration in soils and vegetation is the only strategy that can remove carbon from the atmosphere which in turn will reduces the atmospheric carbon dioxide concentration. The study showed that different soils varies in their sequestration potential and bears a relation with

Figure 1. Biochar trials.

Figure 2. Grain quality under different amendment application.

the land use activities and management to which it is subjected. However, the technical potential of carbon sequestration of soils promises a vast carbon sink or pool in future at the landscape level or regional scales which will be available to facilitate carbon trading, if managed properly. The potential of degraded land to sequester carbon in soil and vegetation carbon pools needs to be promoted even at plot level as this can be a major income source to the farmers and forms a bridge to the future in terms of fuel efficiency.

The role of biochar as a green viable carbon negation option is well appreciated in the study since the results showed a positive response towards soil and vegetation carbon sequestration and yield optimization. This will be a turning point in utilizing the age old traditional knowledge to knock out the issues of present climate change and food insecurity. Hence the trilemma of food insecurity, climate change and soil degradation can be addressed by restoring the SOC pool.

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Creating public awareness about earthquake and precursors

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ABSTRACT

Experience from previous destructive earthquakes in India indicates that the Government Administration comes in picture with the masses only during post-seismic periods. This is mostly for rescue, evacuation and providing food, cloths, tents, blankets, medicine etc. This was seen during Latur (1993), Bhuj (2001), Andaman (2004) and Kashmir (2005) earthquakes etc. Such post-seismic measures do not help in alerting the people and mitigating the seismic disaster. If common people are educated and informed about some reliable seismic precursors, it would help in saving lives of several people. There are some reliable seismic precursors which every person could see. If people are educated they would prepare to face the seismic contingency. A pamphlet for this has been prepared and it is intended to be released in seismically active states in India. The precursory parameters are divided on time axis and not by the nature of the parameters. The Seismo-electromagnetic precursor on reception of radio waves is seen about 60 to 100 hours before earthquake. The same effect for television in the form of audio, visual and spectral disturbances is seen about 10 to 12 hours before the earthquake and the same is found in the form of mal-functioning or non-functioning for mobile telephone about 100 to 150 minutes before the earthquake.

1 Introduction

Abnormal animal behavior is observed about 10 to 12 hours before earthquake. Similarly, human medical precursors are seen about 15 to 20 hours before earthquake. When such precursors are seen at a particular place people should telephone nearby location within about 20 to 30 km radius and verify whether such precursors are also seen at several places in the radius of about 20 to 30 km then it would reasonable to expect the occurrence of a medium to large magnitude earthquake. Appearance of unusual 'earthquake clouds' occurs about 10 to 30 minutes before the earthquake. These clouds are of unusual size, shape and colour. Such informative pamphlet would be translated in the regional language and would be distributed to large number of people. The pamphlet is based on available references from various global earthquakes and personal experience of the author. As the pamphlet is meant for common man, each line has been made as short as possible and is bulleted. This is to be released in few States such as Assam, Tripura, Mizoram, Sikkim, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Himachal Pradesh, Uttarakhand, Gujarat, J & K, Delhi and Andaman & Nicobar. It would be translated in respective regional language in addition to Hindi and English. The points in the pamphlet would be periodically announced on Radio (Akashvani) and Television (Doordarshan). The pamphlet is given below:

2 Earthquake precursors

Keeping in view the present seismic status it is desirable that the common man is informed about some reliable seismic precursors. Details given here are expected to be useful and helpful to common man to save his life. The precursors described in this note are applicable to medium to large magnitude earthquakes, meaning magnitude 6.0 and above earthquakes only. Small magnitude earthquake may not be preceded by these precursors.

There are several seismic precursors and these are divided in three parts (a) Long time precursors: about 3 to 10 years before earthquake (b) Intermediate time precursors: 6 to 12 months before earthquake (c) short time precursors: about one or two week before earthquake and (d) very short time precursors: ten to twenty hours before earthquake. This note would discuss about last two precursors.

3 What is seen about one week or few days before earthquake?

3.1 Water precursors

These are seen during this time. About two to five days before the occurrence of earthquake, water in rivers, tributaries or *Nallas* suddenly undergoes abrupt change in level and discharge. It may increase or decrease depending up on the geology and location of the river. The changes are sudden and abrupt. The water levels in wells change suddenly by one to two meters. Sometimes the well water turns muddy or a fountain is seen coming out from the bottom of well.

3.2 Thermal precursors

These are seen about three to six days before the occurrence of earthquake the local area temperature goes on increasing above the normal temperature. This information about temperature is available in daily weather columns of newspaper. If there is no information about the deviation of temperature then this could be obtained at India Meteorological Department (IMD) web site. Usually there will be a rising trend. For example on first day the temperature may be 3 degrees above normal, on second day it may be 4 to 5 degrees above normal and on penultimate and ultimate day it could be as high as 7 to 8 and 9 to 11 degrees above normal. School and College students can keep a log of daily temperatures and watch the situation.

3.3 Seismo-electromagnetic precursors

Seen about three to six days before the occurrence of earthquake. The magnetic field of the earth is reduced. This adversely affects the transmission, propagation and reception of electromagnetic waves. As a result the reception of radio waves in the potential Epicentral area is disturbed. This disturbance could be seen about three to five days in advance. As an example, if a radio station is broadcasting programme at 1000 kHz then the same radio station would be received in the potential Epicentral area at 1100, 1200, 1300 1600, 1700 kHz or so. If it is difficult to receive your favorite station at the fixed frequency, then try for higher frequencies you may hear the radio station.

4 What is seen a few hours before earthquake?

The wireless communication of various Departments would be disturbed and it may not be possible to receive the transmitted message from one station to the other station. Police, Government and other Departments may experience this type of difficulty. If the magnitude of the earthquake is quite large (7.0 or more) then there will not be any communication, it may experience a blockade of communication. The blockade occurs about ten hours before the earthquake. About ten to fifteen hours before the earthquake, the reception on television would be disturbed and the frequency of disturbances would go on increasing till earthquake occurrence. There would be audio, visual and spectral disturbances on television reception. This type of disturbance is more manifested in antenna reception as compared to cable reception. About ten to twenty hours before earthquake, the reception on landline telephones would be highly disturbed. There would be repeated *khar-khar* noise. If one tries to enquire at the complaint center, he would be told that the system in the exchange is all right.

4.1 Animal precursor

It is seen that about ten to twelve hours before the occurrence of an earthquake, entire zoological kingdom consisting of animals, birds, insects, reptiles become highly disturbed and they are in restless condition. They make shrilling and unusual noise. They move in a directionless manner with fear and apprehension. Birds do not sit on trees or nests but move in groups at a low height with shrilling noise. Rodents such a snakes, rats mongoose etc are highly scared. They come out of their boroughs and hideouts. Domestic animals such as cow, buffalo, dog, cat, horse, donkey, hen, chicken etc want to be free if they are tied. Elephants are very sensitive and abnormal behavior of elephants could be seen immediately. Fishes in ponds and tanks show their disturbed conditions by erratic movements. If the magnitude of the impending earthquake is large (more than 7.0) then the fish try to jump out of pond. Insects such as millipedes, centipedes, ants etc also show signs of disturbed conditions. Normally ants move in one single file but under such abnormal conditions, they move in a stationary circular orbit and moving one over the other. If the owner of the domestic animal goes near the animal, the disturbed condition of the animal is exhibited in the form of attack on the owner by the animal. If domestic animals show any sign of disturbed condition then set them free. All the animals should be set free and not tied or kept in cage. Zoo, national parks, animal sheds, dairies, poultry, piggery, stud farms etc would give useful inputs for abnormal behavior by looking at several species at one time.

4.2 Abnormal human precursor

This is seen and could be observed in hospitals by doctors, nurses and Para-medical staff. It is seen that some sensitive persons are highly disturbed. There is sudden rise in patients of blood pressure, heart trouble, headache, migraine, respiratory disorders and diseases etc. Further these psychosomatic diseases are manifested without any provocation. Some people feel restless. A few have vomiting sensation or they vomit. A number of persons suffer strong attack of headache, that too without any provocation. It is seen that the number of patients in the Out Patient Department (OPD) increase by five to seven times of the average number, about ten to fifteen hours before the quake. The best indicator is number of deliveries in any hospital. On the penultimate day of earthquake the rate of deliveries is about three to five times more than the average, while on the day of earthquake it is as high as seven to eight times the normal rate. In India this rise in number of deliveries was seen before the Latur (Maharashtra) earthquake of 1993, Bhuj (Gujarat) earthquake of 2001 and Andaman earthquake of 2004 and Kashmir earthquake of 2005.

5 What is seen a few minutes before earthquake?

About 100 to 150 minutes before earthquake, the mobile telephones would start malfunctioning or non-functioning. About ten to thirty minutes before earthquake an unusual multicolor glow is seen in the sky known as seismic glow. Sometime, a hallo of circular or oval shape may also be seen. This is seen during day or night time. If there are clouds, it may be difficult to see the unusual seismic glow. Such seismic glows have been seen before large magnitude earthquakes. During recent past, Seismic Glow was seen before Sichuan earthquake of magnitude 8.0 in China on 12 May 2008.

6 What to do if precursors are observed?

If it is seen that

- The entire animal kingdom is showing signs of abnormal behavior.
- Radio and Television reception is disturbed.
- Mobile telephones are non-functioning.
- The medical Doctors observe that the rate of OPD and deliveries in hospital has increased several times more than the average.
- The atmosphere becomes unusual and irritating, and then informs the local authorities.
- Secondly, inquire from friends or relatives by telephone at a distance of 20 to 50 km away from your location whether similar conditions are also prevailing or not at other places.
- If such conditions are observed at several locations (more than fifteen to twenty locations over extended area of 20 to 30 km distance) then it is reasonable to expect that an earthquake may occur any time.
- Under such conditions, one should close all electric, gas and water connections, extinguish *Chula* fire in the house and come on open ground and stay in open away from the collapse range of the house.
- Uncooked food such as Chana, Chidva, Poha, Murmura, Komal Chawl (in NE region) etc may be kept ready while coming out of house. These items do not need any fire, water and salt and could be eaten in uncooked condition. Man could be healthy and active on this food for few days. These items have long shelf life and does not get stale. Have some stock of water bottles and first aid medicines.
- While sitting or standing in open ground try to observe various objects such as trees, clouds, sky. If there is river or *Nalla* observe the flow of water.
- Most Important is not to jump to any affirmative conclusion by observing one parameter at one place.

If the above instructions are followed properly, it would definitely help in mitigating the seismic disaster and save lives.

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Nanotechnology — A new frontier for food security in socio economic development

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ABSTRACT

Agricultural sustainability is facing challenges both in respect to food security and ecological vulnerability all over the world. Day by day food prices increase while the food production seems to be drastically low. This brings out the issues of sustainability covering both agro-ecological and socio-economic indicators. It has been observed that the number of hungry people will be more than one billion by 2015. Nanotechnology is being explored in the field of agriculture to boost production by several companies. Nano particles are engineered materials that operate at a scale of 100 nanometers (nm) or less. Nanotechnology can create breakthroughs in the food sector. But scientists would like to predict that this technology may create some risk in ecological, health and in socio-economic sectors. Nanotechnology may create some toxic effects in food chain, in biomagnification and also in food web. Naturally, the toxicological effects need consideration. The article deals with the prospect of nanotechnology in the food sector as it is related with the socio-economic development. Several reports suggest that the food chain and the normal processes of energy flow is altered by nanoparticles. Nanoparticles have to be used properly to avoid disastrous consequences.

1 Introduction

Nature is a unique phenomena where humans are an important part and naturally their basic needs are food, shelter, clothing and medicines. All the things are coexisted with food only. Thus the agriculture is the main existence in the nature which allow us to get food. Now a days agriculture in India has permitted widespread adoption of genetically improved new seeds, chemical fertilizers, pesticides, intensive irrigation, optimum agronomic conditions and modern machinery to only a few crops. Advances in breeding for crop improvement, higher nutrition, abiotic and biotic stress resistance, post-harvest preservation, etc. have met with limited success. These processes clearly denotes the loss of original seed crops from the nature. Naturally, the natural food products are unable to get in future. In the same way there are several new techniques are developed in the present decade. The present situation of agricultural production faces the challenge of enhancing crop production and providing nutritionally adequate diets for the increasing population, under uncertain climatic extremes, water scarcity, in limited (and degraded at many places) land area, with more requirement of water, and in many cases with poor quality water and air, and rapid erosion of natural biodiversity. To maintain the food quality in relation to its huge production, the food security is also an important factor. The food production, quality and food security can be maintained by introducing small science in the present century. Thus small science have such a big impact, this is nothing but nanotechnology. Now a big question is whether we will apply this technique in the agriculture field or not? The question is why? To get this answered, we have to enter the inner part of this technology, the advantage and disadvantage of this technique.

Nano particles are engineered materials. Its structures and systems that operate at a scale of 100 nanometers (nm) or less (one nanometer is one billionth of a meter) (Moraru *et al.*, 2003; Bhattacharyya and Debnath, 2008; Bhattacharyya, 2009; Bhattacharyya, *et al.*, 2010). This scale helps to denote that a strand of DNA is 2.5 nm wide, a red blood cell is 7000 nm, while human hair is about 80,000 nm wide (Lyons, 2010). The potential role of nanotechnology covers from new materials useful for the textile, packaging, food or transportation industries; nanodevices and nanomaterials for sophisticated medical procedures and treatments or for cutting edge telecommunication and information technologies; all the way to more effective security and military innovations (Roco and Bainbridge, 2001; 2002; Berube, 2006; Datta, 2008). There is no reason to assume that nanotechnology will be different from other industrial innovations when it comes to having the potential to present both benefits and risks to human and environmental health (Maynard, 2006; Dunford 2010).The reality that nanoparticles seem to be more biologically active; nanoparticles' potential to cross cell membranes and interact within subcelluar structures; and the capacity of exposing cellular functions (Colvin, 2002; Poland, 2008). Still, nanotechnology potential carries with its significant concerns as those regarding its safety and adequate use and assimilation by society. Therefore, experts have pointed out the need of an international standardization of the production processes of nanomaterials worldwide. Therefore, the eco-nanotoxicology research is very essential for introducing one responsible and 'smart' regulatory framework in the sense of guarantee through which the safe nanomaterials can be introduced in the human society. It is very essential for the development of the great technology nanotechnology (Zonneveld, 2008; Kjølberg, 2008).

The idea of biosystem building blocks at the nanoscale is yet to be understood properly. In view of these facts, still it can propose that nanotechnology is fast becoming the technology of the future generation. There are great opportunities in applying nanotechnology to agriculture systems, namely, foods, produces, farm animals and the entire subset of agro-ecological constituents. There are, however, potential risks in the deployment of agronanotechnology as well (Lobell, *et al.*, 2008; Pretty, 2008; Dunford, 2010). Thus the development of nanotechnology will explore its beneficial attitude in agriculture/food sector. Nanotechnology applications are being developed that could impact global markets for agricultural, mineral, and other non-fuel commodities. Several authors report that applications of nanotechnology could, for instance, impact global demand or open new markets for commodities. Such developments could have potentially far reaching socio-economic and other effects in developed and developing countries (Dunford, 2010).

Today several nano food products are coming in the market like nanocochleates (50 nm in size) are based on a phosphatidylserine carrier derived from soya bean, generally regarded as safe (GRAS). As it is known that the word cochleates, has been derived from the Greek ward for a snail with a spiral shell, are obtained by the addition of calcium ions to small phosphatidylserine vesicles, which induces formation of discs that are fused into large sheets of lipid and rolled up into nanocrystalline structures. The nanocochleate system is claimed to protect micronutrients and antioxidants from degradation during manufacture and storage. Recently, self-assembled nanotubes have been developed from hydrolysed milk protein like, lactalbumin, which can offer a new naturally derived carrier for nanoencapsulation of nutrients, supplements and pharmaceuticals (Graveland-Bikker and de Kruif 2006). Another major area of current nanotechnology applications is nanoencapsulation of food ingredients and additives. The use of microencapsulated food additives is already well established. For example, microencapsulation has been used to mask the taste and odour of tuna fish oil added to bread for health benefits. In this context, the nanoencapsulation of food ingredients and additives appears a logical extension of the technology into an already existing application area to provide protective barriers, flavour and taste masking, controlled release, and better dispersability for water-insoluble food ingredients and additives. Nanoencapsulated substances are also being developed as part of interactive foods, which will allow consumers to modify the food depending on their own nutritional needs or tastes (Lyons, 2010). Though this technology posses a tremendous effect in the human benefit but still this technology exhibits a risk factor in the ecological system, in biodiversity, in biomagnification, in health and also in socio-economic conditions (Scrinis and Lyons, 2010).

2 Nano food

Food using nanotechnology – nano food – is beginning to make the headlines. News stories have described 'programmable food' including drinks or pre-cooked lasagna containing nanoparticles, in which the colour, taste and proportion of various nutrients can be changed by heating the product with a correctly-tuned microwave transmitter. Then there is the suggestion of getting more children to drink milk by making it taste like cola. Green tea is being processed with the potential for selenium absorption to be increased by ten-fold. Several industry players such as Kraft, Nestlé and Unilever, are busy working on such foods and drinks, made possible due to the emerging science of nanotechnology. Naturally, several other more companies are being used to manufacture several new foods according to dietary needs or food preferences. Nanotechnology is also being used to alter the properties and traits of food; including its nutrition, flavor, texture, heat tolerance and shelf life. For example, Unilever has reported breakthroughs in the manufacture of low-fat low-calorie food that retains its rich and creamy taste and texture, applying this to a range of very low-fat ice-creams, mayonnaise and spreads (Daniells, 2008). Meanwhile, food companies are using microcapsules to deliver food components such as omega 3-rich fish oil. The release of fish oil into the human stomach is intended to deliver claimed health benefits of the fish oil, while masking its fishy taste (Lyons, 2010).

3 Nano food packaging

Nano food packaging is the most commercialized of the agri-food nanotechnologies. Nano packaging materials include barrier technologies, which enhance the shelf life, durability and freshness of foodor at least slow the rotting process. DuPont produces a nano titanium dioxide plastic additive that reduces UV exposure that they claim will minimize damage to food contained in transparent packaging (ElAmin, 2008). This packaging may considered as 'smart' or 'active' packaging which act as antimicrobials and antioxidants of food stored in the package system. In nanotechnology, the carbon nanotubes also can incorporated into packaging system. This carbon nanotube also helps to detect microorganisms, toxic proteins and food spoilage system (ElAmin, 2008; Lyons, 2010).

4 Nano farming

In the present century agri-chemical and information technology industries have taken in account to produce the new agricultural chemicals and seeds etc. in nano device for proper management of agricultural farm. Crop Science, Cargill and Monsanto are all undertaking research and commercialization of nano pesticides which can break the insect stomach alkaline conditions. These nano pesticides are more targeted delivery of pesticides on the specific host. Moreover, nanobiotechnologies are enabling to produce targeted nanoparticles, nanofibres and nanocapsules to carry specific foreign DNA and specific nano chemicals that modify genes of insects and host (Torney *et al.*, 2007). In more recent decade the synthetic biology; a new branch of technoscience that draws on the techniques of genetic engineering, nanotechnology and informatics. Through this technology, researchers can completely replace the genetic material of one bacterium with that from anothertransforming it from one species to another individual (Lyons, 2010).

5 Nano particles and ecological balance

Several nano products like; silver containing antimicrobial products, titanium dioxide (TiO2) and zinc oxide (ZnO) containing sunscreens, pharmaceuticals, and UV protective coatings products etc, are coming in the market and the load of nanoparticles in environment gradually increases. It has been observed that between 2005 and 2010, the amount of nano products employing nanotechnology has increased from 54 to 1015 (Report of Woodrow Wilson International Center for Scholars, 2010). Naturally, the concentration of nanomaterials in the waste streams are increasing steadily through the year (Gottshalk, *et al.*, 2009). The material flow analysis models, clearly denotes that the nanomaterials concentrations in sludge-treated soil will increase from the year 2008–2015 (Gottshalk, *et al.*, 2009; Judy, *et al.*, 2010). More experiment in the present decade helps to understand that nanoparticles can enter in plants, in gastrointestinal region and also can take part in transmembrane transport (Chithrani, *et al.*, 2006). Now it is clearly established that nanoparticles are available from lower trophic levels to terrestrial food webs (Holbrook *et al.*, 2008; Zhu, *et al.*, 2010; Unrine, *et al.*, 2010). Moreover, recent experiments helps to denote that a particular size of nanoparticles like, gold, copper etc, can transfer from Daphnia magna to earthworms to Danio rerio (zebrafish) and also take part in biomagnification (Zhu, *et al.*, 2010; Unrine, *et al.*, 2010; Judy, *et al.*, 2010).

The above information denotes that the biomagnification (also known as bioamplification or biological magnification) in the nature increases due to deposition of nanoparticles in several minute organisms of the food chain/food web models (Bobrow, and Fisher, 2009). Recent scientific study clearly denotes that the several nanoparticles like cadmium, selenide and quantum dot etc. can enterin in to the bacteria and also can take part in biomagnification by certain specific mechanism. Thus nanoparticles containing bacteria is being incorporated in protozoa. Then nanoparticles containing bacteria are being stored in protozoa or in the primary consumer. Therefore, the above findings helps to propose us that nanoparticles are the regular phenomenon for entering in the ecological food chain or in food web which leads to produce inhibition of energy flow/ecological imbalance in the nature (Werlin, *et al.*, 2010; Holden, 2010).

6 Conclusions

The nano-technology is driving a high-tech approach to farming entrench a chemical, industrial and corporate agri-food system. It is essential that we will invite the new technology, but at same time it is our duty to look out the process of use of these materials in different sectors. The food is an important factor for socioeconomic development where different experiments are still in process. Our above discussion helps us to understand that whatever the nanoparticles we are using in agri-sectors that will come from agricultural field to primary producer to primary consumer. Thus it will hamper the entire ecological balance which can create a disaster in eco-friendly processes. Moreover, it is obvious to propose that most of the studies on application of nanoparticles in food sectors and also in other related fields are currently being performed in the USA, Australia, New Zealand, South Korea, Taiwan, China and Israel. It is very sorrow to propose that no proper information has been gathered from Indian region. Naturally, it is obvious that the time has come to introduce the proper new techniques in India for getting information regarding toxicity effect of nanoparticles in food sector/other several sectors which helps us to think not only for maintaining the food quality but also will help to maintain the eco- factors of the society in future.

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Geotechnical assessment of landslides in the Bageshwar district of Uttarakhand, India

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ABSTRACT

Numerous landslides, land erosion and subsidence occurred at different places of Bageswar, Uttarakhand in the month of September 2010 initiated by heavy rainfalls and cloud burst resulting in 19 deaths, widespread damage to human settlements, cultivated lands, irrigation canal, bridge, village foot tracks and major communication routes. More than 50 major landslides classified as rock slide/fall, debris slide, rock-cum-debris slide, and slope wash debris flow and bank erosion of different nalas/streams have been recorded. The slides have resulted in huge debris flows that flooded and deposited sediments over human settlement, communication routes and cultivated lands. The data reveal that steep slopes, high relief, thick slope wash material/overburden, complex fold, numerous faults and proximity to thrusts have rendered the slopes highly vulnerable to mass movements. Further, anthropogenic activities and varied geological, hydrogeological, slope erosion and structural conditions have created adverse conditions for numerous debris slides/falls. Special reference is made to the 18 September 2010 landslide that hit a primary school, at Sumgarh village, *Tehsil Kapkot* where 18 children died and over 25 children were severely injured.

1 Introduction

In September 2010 and subsequently, many disastrous landslides, bank erosion, landslips with subsidence and widespread cracks in cultivated terrace slopes and houses have developed around many places in district Bageswar, Uttarakhand. Similar incidence has struck a primary school, Saraswati Shishu Mandir, at Shumgarh village in Kapkot *tehsil*, Bageswar district, Uttarakhand.

The paper has discussed with special reference to landslide named as a '*killer landslide*' preceded by a cloudburst occurred in primary school, Saraswati Shishu Mandir, at Shumgarh village Kapkot *tehsil*, Bageswar district, Uttarakhand.

The paper summarizes the findings of preliminary geological investigations/assessments carried out at Shumgarh village and other landslide affected areas to identify the potential causative factors and suggest suitable remedial measure for slope stabilisation. These assessments will also facilitate to find out the physical vulnerability of affected slopes being utilised for human activities.

2 Geomorphological set up and regional geology

Geomorphologically, the area comprises steep slopes, rugged and highly dissected hills with youthful and deep valleys, rising to a maximum elevation of nearly 2306 m at upper reaches of Shumgarh village and minimum about 1254 m at Basi village.

The affected area exhibits steep to moderate $26° -> 35°$ slope angle, high relief, rugged topography covered with densely to moderately vegetated mixed forest mainly pine. The area is mainly drained by Sarju *River*

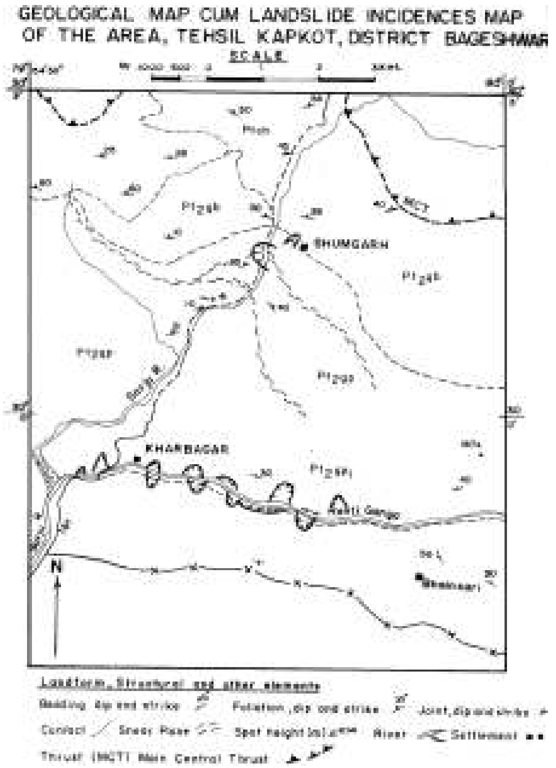

Figure 1. Pt2gb-Quartzite intercalated with slate and phyllite and calcareous quartzite Berinag Formation; **Pt2gt/Pt2gp/Pt2gp**1-Limestone, dolomite and magnesite, marble with intercalations of shale slate phyllite and calcareous quartzite of Tejam (≡Pithoragarh) Formation; schist, **Ptch**-Augen and porphyroblastic gneiss, marble and quartzite of Helang Formation of Central Crystalline Group.

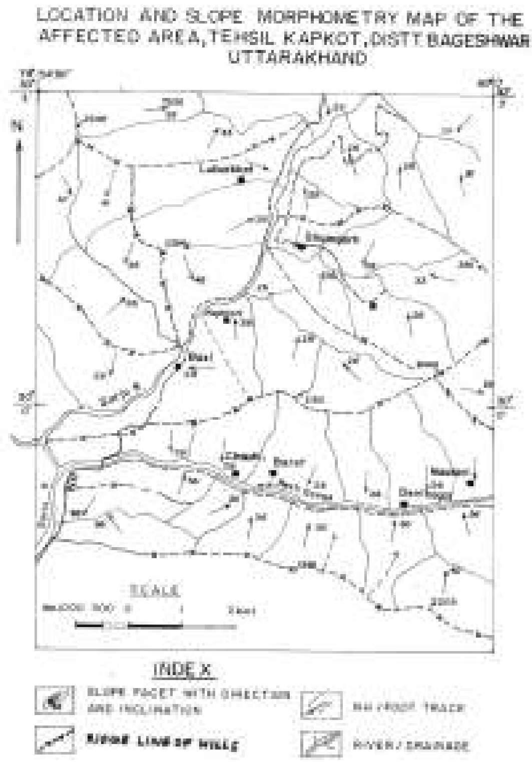

Figure 2. Slope facet represents a uniform slope bounded by ridge line of hills, drainage or break in slope. Slope morphometry showing general slope of the area irrespective of the direction. The angle of slope inclination and the direction of slope inclination are marked in each slope facet, show steepness of slopes. Slopes are steep to moderate 26°– > 35° angle, vulnerable to failure.

flowing ENE-WSW and its tributary Revti *ganga* flowing almost E-W joins at Rithabagar village, Kapkot *tehsil*. Numerous streams join the Sarju river which together form dendritic to sub-dendritic drainage pattern (Figure 1).

Geologically, the rocks exposed in the area belong to Central Crystalline Group of Proterozoic age and Garhwal Group of Mesoproterozoic age. The expose area comprises schist, augen and porphyroblastic gneiss, marble and quartzite belongs to Helang Formation of Central Crystalline Group; white, grey, brownish quartzite intercalated by slate and phyllite and calcareous quartzite with associated volcanics of Berinag Formation; limestone, dolomite and magnesite, marble with intercalations of shale slate phyllite and calcareous quartzite of Tejam (≡Pithoragarh) Formation belong to Garhwal Group. The main structural discontinuity running through the entire length of Uttarakhand is Main Central trust (MCT) traceable at the upper reaches of Shumgarh village. The MCT has brought the Central Crystalline in juxtaposition with rocks of the low grade complexes and, in a sense, marks the southern boundary of Higher Himalaya. Apart from regional thrust a number of shear fractures/plane in parallel and en-echelon patterns trending WNW-ESE to E-W are disposed in the area. The general trend of the rocks varies from NW-SE to E-W with low to moderate dips and high angle at places towards north and NE as well as south due to folding. Four sets of joints have been recorded in this area: J1)-E - W/high angle (60° toward NE) to vertical dipping, J2)-N - S/high angle (45° toward East) to vertical, J3)-NE - SW/high angle (45° toward SE) to vertical, J4) - NW - SE/vertical.

3 Geological assessment of affected sites with causes and remedial measures

3.1 Landslide at Shumgarh village

The slide is located on the Bageshwar - Pindari Glacier road, 45 km from Bageshwar on a hill slope at elevation of nearly 1400 m, at the right bank of Sarju river in Kapkot *tehsil*, Bageswar district, Uttarakhand (Figure 1). The slide occurred on the southwestern slope of east west tending ridge. The inclination of slope is 29° falls in moderate to steep slope (25°-35° slope angle). Three minor local seasonal drainages are draining the slope. The width of the slide is about 15 m along the school and length of the slide from school ground to the crown is about 25 m (Figure 1 and Photos 1 and 2).

The disaster occurred on 18 September 2010, during school time at around 8.30 am when a loud thunder,

Photo 1. Photo-1 Rock cum debris slide/flow at the right bank of Sarju River at Shumgarh village.

Photo 2. Wash out of link road connecting the school and abutment of iron bridge.

followed by the landslide triggered rock debris. Within no time the entire school turned into a graveyard. 18 children of Classes I and II died (buried alive under tonnes of rock debris) and over 25 children got severely wounded. A link road connecting the school and abutment of iron bridge had also washed away due to over flowing of Sarju river and other adjacent steam flowing at the left bank of Sarju river. The process of exhuming bodies from the debris was carried out manually since the no machinery could reach there. Officials and rescue workers reached the accident site after walking for over 6-miles.

3.2 Landslide in Revti *ganga* valley

The entire valley of Revti *ganga*, a tributary of Sarju river has been affected by intense rainfall in September 2010 and subsequently (Photos 3, 4, 5 and 6).

Photo 3. Landslide in Revti *ganga* valley.

Photo 4. Landslide in Revti *ganga* valley.

Kharbagar and Breta villages were particularly affected by rock cum debris slide. The entire stretch of road between Kharbagar Naukri was severely affected due to major landslide and bank erosion of Revti ganga. A 100 m long stretch of road was badly destroyed near Kharbagar connecting the Bageshwar - Pindari highway. An old lady died over roll down of a rock boulder. Mostly slope failures have occurred on the right bank of Revti ganga severely affecting Kharbagar, Baret and Devibagar villages (Figure 1). Whole civil supplies and transport activities were disturbed for long time. The dominant slope forming material in the valley includes calcareous and secricitic quartzite and slate of Tejam (≡Pithoragarh) Formation of Garhwal Group with thick overburden of glacio- fluvial deposit. The trace of the share zone/plane passes through this affected zone.

Similar incidences, at many places roads were repeatedly blocked due to rain-triggered landslides. Bageshwar-Pindari glacier road is the main communication link and a civil supply to the area was totally disrupted after collapsing of 200 m long road stretch before Shumgarh village. The debris flowed further down the slope and spread into the cultivated land. The affected slopes are covered by thick overburden of glacio-fluvial deposit resting on very steep slope (46° slope angle). The trace of the share zone/plane passes through this affected slope (Figure 1). All the communication services were remained cut off for several days due to this landslides led by torrential rains.

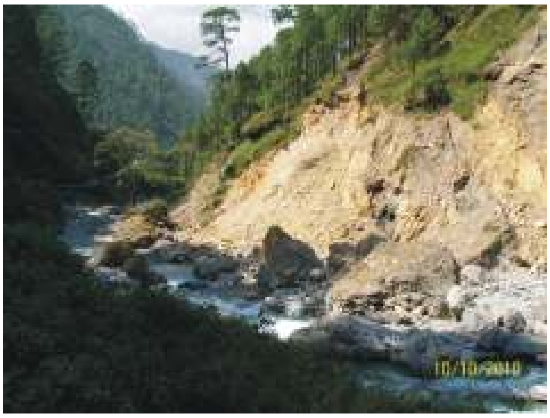

Photo 5 and 6. Photographs 3, 4, 5 and 6 showing landslides on either side of Revti *ganga* valley; a stretch of road, badly destroyed near Kharbagar connecting the Bageshwar - Pindari highway.

4 Causes of slide

4.1 Shumgarh village

- Overburden and sheared phyllite present as intercalation between competent rocks is bound to come in slip-squish mode during heavy rains. Intense rain facilitated the slide by working as lubricant between competent rocks. As a result, sheared phyllite and debris material/overburden charged with water and squeezed out with loud thunder and rushed as a landslide hitting the school building located at the toe of slide and within no time the entire school turned into a graveyard.
- The presence of shear zone adjacent to the slide affected area and contact zone of the formations passing exactly where the slide occurred, are also important geological factors contributing to sliding of rock mass.
- The rainfall data reveals that till 18th Sep. 2010, the Uttarakhand state had received the average rainfall 901.7 mm, against the normal rainfall of 853.2 mm. which was 56 per cent higher, which caused disastrous landslides with severe widespread damages.

4.2 Revti *ganga* valley

- The most important causative factor for the triggering and development of landslide is the continuous heavy rainfall. It has led to the over saturation of thick deposits of slope wash debris material and with the increasing pore water pressure by percolating water into these materials, the shear strength of these materials has reduced significantly. Other factors being, bank erosion and toe cutting of Revti *ganga* during high flood, causing slope failure.

4.3 Suggested remedial measures

- It has been suggested to remove the material from school building area. After removing the material, construct the concrete breast/toe wall, to provide the additional stability of the affected slope as well as protection of school building from further sliding of material.
- Construction of retaining wall/wire crates in Revti *ganga* valley along the affected stream bank with high and deep foundation. These structures will protect the terrace bank from stream erosion by Revti *ganga* during high flood. This practice will protect the bank of Revti *ganga* from stream erosion.

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Flood freqnecy analysis of Rohini river in East Uttar Pradesh

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ABSTRACT

The present study aims at estimating the flood values for different return periods for River Rohini in East Uttar Pradesh under the changed climatic conditions. In order to achieve this task, initially a conceptual Rainfall-Runoff model namely, ARNO model was calibrated and validated to the observed data (1990–1995). Further, the calibrated model was used to simulate the flows for a period of 2007–2050 with projected rainfall and evaporation from climate change scenario obtained from GCM's. This analysis uses the scenarios A2 and B1 for the region. The observed and simulated annual peak runoff values were then subjected to flood frequency analysis using the L-moments method. Estimated flood quantities for various return periods from 2–200 years varied from 420–1882 cumecs during historic period and between 887–1777 cumecs for the projected period. The results obtained show that there are possibilities of more frequent large volume flood events to occur in the coming years due to induced climate change. The results of this analysis would be of great importance as this can be used in planning the flood mitigation activities. The methods used in this study are simple and can be used when limited data are available.

1 Introduction

Flood is a natural calamity, which has been affecting the mankind for centuries around the world. In India most of the northern states, especially the East Uttar Pradesh is suffering from the effects of flood damage in recent years. The major flood events of the last decade have observed during the years 1998, 2001 and 2007. There have been several attempts made to minimise the damage caused by these floods in the area. Due to the non-availability of hydro-meteorological data, the estimates of flood quantiles were not accurate so the planning for minimising the damage were not effective. Therefore there is an urgent need for reliable estimation of flood peaks with given return period. The accurate estimates of the flood values depend on the availability of hydro meteorological measurements across the catchment area. The Rohini River in Uttar Pradesh district is prone to floods during monsoon season which has brought countless disasters to the inhabitants who have been historically occupied in the banks of the river. But sparse network of rainfall and streamflow measuring stations and unavailability of data from up-catchment area in Nepal region, lack of small scale topographical and cadastral maps together with other relevant information are leading to incorrect and inaccurate estimation of the flood potential. In the absence of such information, hydrological models can be used to estimate flood frequencies which would help to achieve effective disaster reduction.

The present study, an attempt is made to estimate the flood frequencies of the Rohini River catchment using the available data on rainfall, runoff and other topographical characteristics. Such information would be extremely useful to minimize the damages induced due to floods and also for timely precautionary measures to be taken.

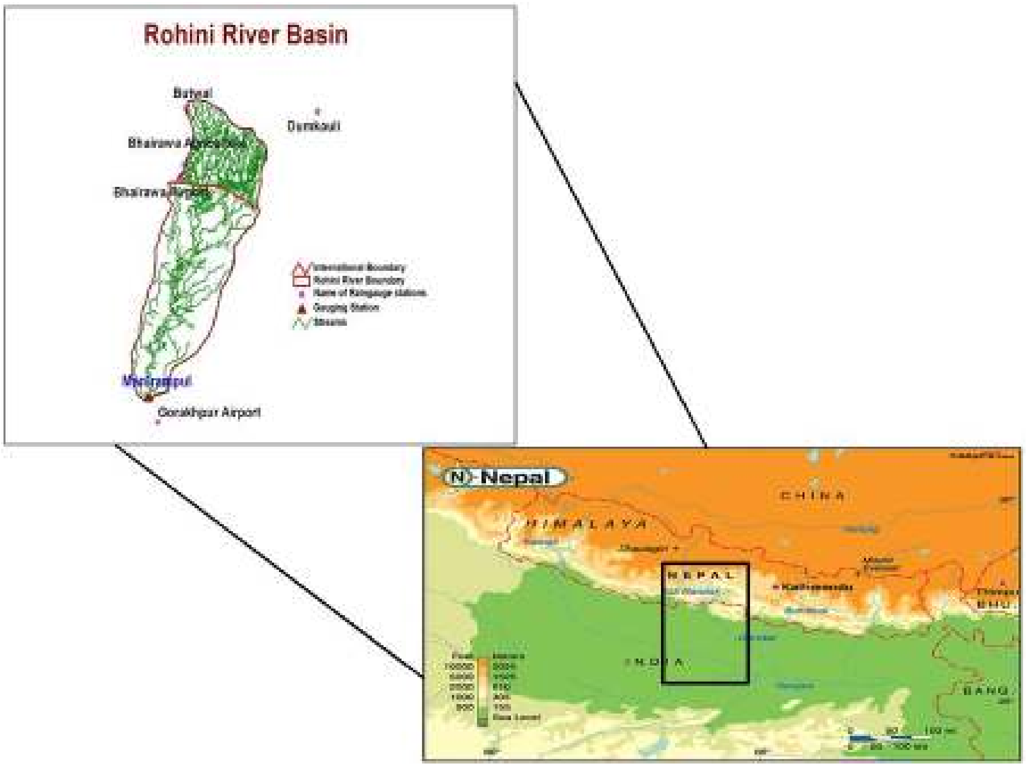

Figure 1. Location and features of the Rohini Basin.

2 Study area

The Rohini River catchment originates from Nepal Terai has a total drainage area of 2686 sq. km of which 1945 sq. km lies within India. Starting in Nepal, the river flows approximately north to south and after crossing the Indian border the river ends at its junction with the Rapti River near Gorakhpur City. The climate of the area is monsoonal. The temperature ranges between 5° and 46°C, and average rainfall is approximately 2000–2200 mm/annum, over 80% of which falls during the monsoon. July and August are the wettest months, receiving about 60% of the monsoon season rainfall. Average runoff from the catchment is about 19023 cumecs equivalent to 609 mm with a runoff coefficient of 0.29. Though the river drains only 30% of the catchment area within Nepal, the contribution of runoff from Nepal is more than lower catchment in India, because Nepal catchment receives more rainfall. The location of the basin and its features are shown in Figure 1.

Daily rainfall data available for five stations for the period 1982–2005 were used in conjunction with stream flow data at the gauging point Manirampul near Gorakhpur. The average density of rain gauges is about one in 540 sq. km. The topographic maps were used to demarcate the catchment boundary and also to generate the stream layer. For generating height information and contours in the Rohini river catchment, NASAs Shuttle Radar Topography Mission (SRTM) data were used. These data provide elevation information at a spatial resolution of 90 m. Using the information available, the digital elevation model (DEM) was created using standard GIS packages and the contours @20 m interval were generated. Soil and topographic information available for this region were also made use of for runoff modelling.

3 Methodology

Average rainfall for the catchment was estimated using Thiessen polygon method after scrutinizing and correcting errors in the rainfall data. Streamflow data has been checked for any abnormal values. The catchment average rainfall and streamflow data were then used to establish the rainfall - runoff relationship using ARNO model. This is a semi-distributed continuous time scale model widely used recently as a basic tool for several applications such as extreme floods, water master planning and general circulation (GCM) models. The model is a parametric description of main hydrological processes at the catchment scale such as infiltration, evapo-transpiration, drainage, percolation, routing etc. and can represent catchment as a tree shaped cascade of sub-catchments. The structure and details of the model are presented elsewhere Todini (1996).

Using the available rainfall, temperature, evaporation data and topographic information, the required model parameters are estimated. Evapo-transpiration is calculated using Thornthwaite and Mather (1955) method. The model is initially calibrated and rainfall runoff relationship was derived. Using the model coefficients the ARNO model was then validated. After establishing the rainfall-runoff relationship, the rainfall series for the future period 2007-2050 generated using CGCM3 climate change scenarios A2 and B1 as

Table 1. Flood frequency estimates for various return periods using L-moments method.

Return period (yrs)	Flood quantity (m^3/s) Historic	Flood quantity (B1R3) (m^3/s)	Flood quantity (A2R3) (m^3/s)	Flood quantity (A2R1) (m^3/s)	Flood quantity (B1R4) (m^3/s)
2	420	932	887	942	1050
5	686	1083	1006	1092	1218
10	886	1183	1085	1191	1328
25	1164	1310	1185	1317	1468
50	1389	1404	1259	1410	1572
100	1627	1497	1332	1503	1675
200	1882	1590	1405	1595	1777

supplied by Winrock International (2008) were used. These rainfall series were developed using statistical downscaling model to investigate the potential climate change impacts on precipitation pattern. The rainfall data for A2 and B1 scenario were used in flood models. Detailed procedure for rainfall generation is available with Stapleton and Gangopadhyay (2010).

The rainfall and evapo-transpiration series were then derived as

$$\text{P or ET} = \mu + \sigma \Sigma r_i - r_{i+1}$$

Where

μ mean of rainfall

σ std. deviation

r_i ith Random number

[P or ET] – Simulated rainfall/evapo-transpiration series.

Using the results of ARNO model, the daily streamflow were generated for the forecast period which was further used in forecast of flood frequencies. The annual maximum one day flows were extracted from daily stream flow values. These values were used in the estimation of flood frequencies using the most popular L-moments (Hosking 1990, Jaiswal *et al.* 2003, Rakesh *et al.* 2003, Rakesh and Chattarjee, 2005, Rakesh 2006, Noto and Loggia 2009).

4 Results and discussion

A rainfall runoff relationship is established using the ARNO model. The model is initially calibrated for the period 1990–1993 and model parameters were established. The plot of observed and predicted flow in the Figure 2 showing a good fit for the model. To check the efficiency of the model, the coefficient of correlation, determination, RMSE and MAE were estimated between observed and predicted flow. The coefficient of determination between the observed and the predicted flow for the calibration period were found to be 0.829 with a RMSE of 86.48 and mean absolute error MAE of 52.67 showing a good fit for the model.

The model is then run for validation period 2002–2005. The hydrographs of observed and predicted flow were compared and are presented in .

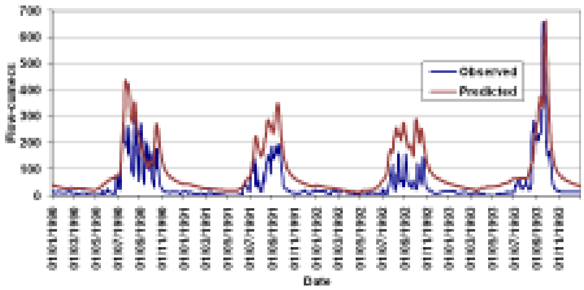

Figure 2. Observed and predicted flows-calibration.

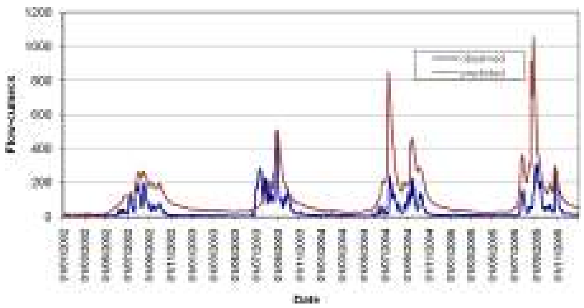

Figure 3. Observed and predicted flows-validation.

The estimates on goodness of fit for the validation showed that the correlation between observed and predicted flow is 0.80 with a coefficient of determination of 0.65, RMSE of 121.21 and MAE of 71.84 concluding a good fit for the model.

The rainfall series projected for the period 2007–2050 were used to generate the future flows. These series for two climate change scenarios A2 and B1 were used separately to generate flow series. The flows were generated using ARNO model coefficients for different runs A2R1, A2 R3 and B1R3 and B1R4 and the flood frequencies were estimated for these scenarios using L moments method. The flood frequencies obtained from historic data as well as for various runs for different return periods have been presented in the Table 1. From the Table 1, it is noticed that, there are increased flood events and their magnitude, for ex. B1R4 scenario generated the highest flood magnitude at lower return period (upto 50 yrs), however, higher return period yielded lower flood magnitudes. Also, the other scenarios have produced higher flood magnitudes indicating the chance of increased flood events and an increase in their magnitude. The reason for the increase in the magnitude is the increased rainfall intensity during the year 2007–2050.

5 Conclusion

This paper presents a procedure tailored for the Rohini River catchment in East Uttar Pradesh focusing to develop a flood analysis for different return period. The study use rainfall-runoff modelling approach. The rainfall and temperature generated through statistical downscaling method from CGCM3 model for A2 and B1 climate change scenario has been used to project streamflow series. Daily streamflow data generated has been further used in flood frequency estimation using the L-moments method. The different return period values may of use in planning the flood mitigation activities. The methods used in this study are simple and can be used when limited data are available and these findings will contribute to formulating the regional development strategies for policymakers and stakeholders in water resource management against the menaces of frequently emerging floods.

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Role of emergency preparedness in industrial & chemical disaster management

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ABSTRACT

Emergency management is a continuous process by which all individuals, groups, and communities manage hazards in an effort to avoid or reorganize the impact of disasters resulting from the hazards. The main attributes of a disaster include unpredictability, unfamiliarity, speed, urgency, uncertainty, threat etc. Accidents in Chemical industry can occur due to human errors, leaks, failure of vessels/equipments or pipelines, lack of safety measure etc. In addition, natural hazards pose an additional risk for industrial accidents. In any disaster, there is an element of surprise. Emergency preparedness is aimed at training people in overcoming this surprise element so that there is a well defined action plan for minimizing the impact of hazard/disaster. It also focuses on minimizing the effects of the incident on person, property and environment.

In industry, one of the main measures of preparedness is the enactment of handling the emergency situations as mock drills. These mock drills are planned and rehearsed for all possible emergency situations within the industry. A detailed action plan on the activities at site and outside, including rescue operation, hazard containment, safe assembly points, coordination with statutory authorities with specific roles for Emergency coordinator & Rescue operations coordinator etc will be charted out in advance. A safe place should be predetermined as assembly point where personnel evacuated from the affected areas are to be assembled. Depending on the severity of the situation '*onsite*' or '*off site emergency*' is declared. Main elements of Emergency plan include Leadership and Administration, Role and Responsibilities of Key Personnel, Emergency action, Protective and rescue equipments, Communication, Medical care, Training, Periodical revision of plan etc. This paper focuses on the Role of Emergency preparedness in Industrial & Chemical Disaster Management in Kerala. The whole scenario is observed from the view point of a production engineer in a Chemical industry in the Cochin industrial belt. As the concept of 'Zero Risk' simply does not exist in the practical world, we have to strive hard to reduce risks and manage crises more efficiently so that hazards do not degenerate into disasters.

1 Introduction

The growth of Industry is a vital element in the development of any nation often measured in terms of its GDP growth. Industrial growth is essential for meeting the basic needs for human survival *viz.* food, clothing and shelter coupled with agricultural and infrastructure growth. Rapid industrialization carries with it the potential of increased hazard, risk and susceptibility to accidents. With the increased growth in population and growth of residential areas close to industrial sectors, the risk of exposure of a larger segment of society to the effects of possible disasters has also increased. This calls for an integrated approach aimed first at eliminating or reducing the probability of occurrence of disasters and also mitigating its effects, if in spite of the best practices followed, a disaster should occur. The first phase normally called the preventive phase is generally taken care of in the design of the industry or plant where all safety measures are incorporated to eliminate the chances of disasters. The second phase aims at preparedness, rehearsal and awareness of the steps to be taken in the case of disasters, aimed at containing and alleviating loss to property and life.

Hundreds of lives and billions of dollars are lost annually because of accidents. Among the industrial sector, the chemical industry by the nature of its dealing with potentially hazardous and dangerous chemicals holds a very high threat probability for accidents or disasters. Accidents in the Chemical industry can occur due to human errors, leaks, failure of vessels/equipments/pipelines, static electricity, hazily carried out modifications, imprudent operating procedures, faulty designs, incorrect material of construction, lack of safety measures etc. (Kletz, 1986). In addition, natural hazards pose an additional risk for industrial accidents. The concept of Zero Risk Potential is perhaps mostly an idealized concept which is practically not achievable. This hard fact of life throws open the need for preparedness and planning for mitigating and\ containing any likely emergency to restrict the damages and effects of the disaster to the minimum, protecting human life and property.

2 Chemical industry and the significance of safety

In the chemical industry, safety is always given utmost priority both at the design stage and during its normal operation. Documented procedures are maintained for normal running, shut down including emergency shut down and start up. All these focus on safety as the prime concern and there is a 'Safety first' concept in handling of Hazardous chemicals and emergency situations. Safety is defined as 'Protection of physical health of people in the organization and prevention of work related injuries and accidents'. Propagation of the culture of safety among the employees is primarily considered as the responsibility of the management. Safety measures prevent accidents and ensure regular flow of work. In turn, it helps, to increase not only the workers morale but also productivity of the organization.

Major Accident Hazard (MAH) installation means, isolated storage and industrial activity at a site , handling (including Transport) of hazardous chemicals equal to or in excess of the threshold quantities specified in schedules. Frequency rate and Severity rate are the two indices for measuring the safety potential in industry. The frequency rate can be expressed as the lost-time due to accidents per million man-hours worked; the severity rate is the number of days lost due to accident per million man-hours worked (Mohanty, 2008).

The worst disaster in the history of chemical industry In India, the Bhopal gas disaster in December 1984 which resulted in the death of several thousand people incited a genuine need to approach Chemical disasters and Disaster Management in a holistic manner. It triggered a worldwide awareness and brought in a new regulatory frame work and techno legal regime towards understanding environmental and disaster challenges within the framework of sustainable development. After this, the Factories Act has been amended and provisions relating to hazardous processes have been added to the Factories Act covering all hazardous process industries. Under this provision, every occupier shall draw up an On-site Emergency Plan and detailed disaster control measures for his factory and make it known to the workers employed therein and to the general public living in the vicinity of the factory, the safety measures required to be taken in the event of an accident taking place. This is the statutory provision laid down in the act for preparation of on-site Emergency Plan to control disaster in the factories. The plan should cover all types of major accident/occurrences and identify the risk involved in the plant. Mock drills on the plan should be carried out periodically to make the plan foolproof and persons are made fully prepared to fight against any incident in the plant.

2.1 Emergency preparedness

The major component of Emergency preparedness is a formal written Emergency plan which, on the basis of identified potential accidents together with their consequences, describes how such accidents and their consequences should be handled, either on-site or off-site (OECD, 2003). In any disaster, there is an element of surprise which in turn leads to shock and numbing of thought. Emergency preparedness is aimed at training people in overcoming this surprise element so that there is a well defined action plan for minimizing the impact of Hazard/disaster. The main objectives of an Emergency plan are to control/contain the effects of the incident and if possible eliminate its probable occurrence. It also focuses on a range of time-sensitive tasks that need to be undertaken involving efforts at all levels, minimizing the effects of the incident on person, property and environment.

On-site emergency: If an incident takes place inside a factory and its effects are confined to within the factory premises, involving only the persons working in the factory and the property inside the factory it is called as On-site Emergency.

Off-site emergency: If the accident is such that its effects inside the factory are uncontrollable and it may spread outside the factory premises affecting the local populace, it is called as Off-site Emergency. An offsite emergency could also occur during the transportation of hazardous chemicals on the road. On such occasions prior training and preparedness are vital to contain the effects of the incident and prevent any untoward incidents.

Before making the on site and off site emergency plan, a HAZOP study has to be carried out by a team of experts consisting of representatives from Production, Maintenance, Fire & Safety, Projects & Design etc to

Table 1. Large & medium chemical industries in Kochi.

Industry	Sector	Major Chemicals Handled	Demonstration of Mock drills/Emergency Plans
FACT	Fertiliser & Petrochemical	Ammonia, Sulphuric Acid, Phosphoric Acid, Benzene, Cyclohexane	Multi divisional - Mock drills onsite/offsite emergency plans in all production Divisions
BPCL - KR	Oil -Refinery	Crude oil, Petrol, Diesel, Naphtha, Benzene, Furnace Oil	Mock drills onsite/offsite emergency plans demonstrated
HOC	Chemicals	Benzene, Phenol, Acetone	Mock drills conducted
HIL	Agro Chemicals	DDT, Endosulphan	Mock drills conducted
TCC	Chlor Alkali	Chlorine , Hydro Chloric acid, Caustic soda	Onsite/offsite emergency plans demonstrated
Binani Zinc Ltd	Chemicals	Sulphuric Acid, Zinc, Cadmium	Onsite emergency plans demonstrated
Merchem Ltd	Chemicals		Mock drills conducted

identify the potential hazardous situations that could occur in an industry and to find out possible control and mitigation measures. In industry, one of the main measures which foster preparedness to meet emergencies is the enactment of mock drills. These mock drills are planned and rehearsed for all possible emergency situations within the industry. A detailed action plan on the activities at site and outside, including rescue operation, Hazard containment, safe assembly points, coordination with statutory authorities with specific roles for Emergency coordinator & Rescue operations coordinator etc will be charted out well in advance. Special focus will be given in the usage of personal protective clothing and equipment (PPE) during the handling of chemical emergency. A safe place far away from the plant should be pre determined as assembly point where in case of emergency personnel evacuated from the affected areas are to be assembled. Depending on the severity of the situation '*onsite* or off *site emergency*' is declared.

2.2 National disaster management authority (NDMA)

In order to inculcate a culture of preparedness among the community and first responders, to facilitate the State Governments in reviewing the adequacy and efficacy of Disaster Management (DM) plans of districts/ Major Accident Hazard (MAH) units and to identify gaps in the resources, communications and systems, NDMA, in coordination with the States has taken the initiative of conducting mock exercises on various types of disasters in the country (NDMA, 2007). The emergency preparedness initiative under NDMA started with the first mock exercise on an Industrial disaster in Noida on 6th June 2006. Till July 2010, 180 mock exercises have been conducted in 84 districts from different States/Union Territories, including 49 in MAH units. The lessons learnt during these mock exercises are discussed in detail, during the review session after the mock exercise, where independent observers and heads of all stakeholders take part. The After Action Report (AAR) is sent to the State for follow up action and for taking remedial measures.

Readiness to swiftly act in compliance of the stipulations of Disaster Management Plan is the main end result expected from the mock drills. Special focus is set on readiness in terms of

- Role clarity as per organogram
- Chain of command & communication
- Mobilization of emergency services for evacuation etc.
- Interfacing between onsite & offsite counterparts

3 Cochin scenario

Cochin is home to many large and medium scale industries ranging from ship building to chemicals and petrochemicals making it the industrial capital of the state of Kerala. Major Chemical Industries in Ernakulum include The Fertilizers And Chemicals Travancore Ltd (FACT), BPCL-Kochi Refinery, Hindustan Organic Chemicals, Hindustan Insecticides Limited (Central Government organizations), TCC (State Government PSU) , Binani Zinc & Merchem (Private Sector) etc. Also the roads of Cochin are lined with a number of vehicles transporting hazardous chemicals to and from these industries. On an analysis, all these major Chemical industries are focusing on emergency preparedness and mock drills are conducted on a regular basis (Suraksha, 2010) which are given in Table 1. A list of emergency plans conducted by the Fertilizer major - FACT Ltd, during 2008 2010 detailed in Table 2, gives a clear indication that diverse chemical emergency scenarios are considered for scheduling mock drills as a part of Emergency preparedness.

Table 2. Emergency plans conducted in FACT Ltd during 2008–2010.

Date	Division	Scenario
07-01-2008	FACT Udyogamandal	Ammonia leak - Ammonia Plant
17-04-2008	FACT Cochin Division	Chlorine leak at water treatment plant
13-07-2008	FACT Petrochemical Division	Un-announced mock drill, Toxic release (Benzene) from Caprolactam Plant
07-11-2008	FACT Cochin Division	Ammonia leak at Ammonia Handling section
27-01-2009	FACT Petrochemical Division	Fire in Captive Power plant - Fuel Oil pump house
20-07-2009	FACT Cochin Division	Fire at Sulphur Handling section
05-11-2009	FACT Udyogamandal	Un-announced mock drill, Oleum leak in Ammonium Sulphate Plant
14-11-2009	FACT Petrochemical Division	Toxic release (Ammonia) from Ammonia unloading station
08-02-2010	FACT Cochin Division	Ammonia leak at Ammonia Transfer pump
08-08-2010	FACT Petrochemical Division	Fire & Explosion in thermal Oil furnace of Anone Plant
19-10-2010	FACT Udyogamandal	Ammonia Leak (Flange leak) in Ammonia Plant

The first off site emergency plan conducted by the National Disaster Management Authority (NDMA) in the industrial sector was based on an imaginary chemical disaster at Cochin combining three major chemical industries viz Travancore Cochin Chemicals (TCC), Hindustan Insecticides Limited (HIL) and Fertilizers and Chemical Travancore Limited (FACT). The event was planned between 11 a.m. and 12.40 p.m. on Tuesday 07-01-2008. Reports of ‘chlorine leakage’ at TCC came in first, followed by ‘thynol chloride leakage’ at HIL and finally, ‘ammonia leakage’ from FACT. Following this, District Collector rushed to the scene and a control room was quickly set up under his direct supervision at the FACT training centre. The ‘situation’ in all the three units could be brought under control within 20 minutes of the occurrence of the ‘disaster’ due to the ‘timely intervention’ of the District Disaster Management Authority. During the year 2009, NDMA focus was on testing the district administration’s preparedness in case of an urban flood in the district of Alappuzha.

Prior inspection is done annually in major chemical industries by a team under the Directorate of Factories and Boilers and Chemical inspectorate. Special focus will be given on Safety in operation, Maintenance, House Keeping, usage of Personal protective Equipments etc. A compliance report is to be filed by the industry to the Directorate of Factories and Boilers on the implementation of the recommendations of the inspection committee. Safety audits are also conducted by in house experts in the specific industry to identify unsafe practices and potential hazard points. The major points to be focused in Industrial disaster management include restricting hazardous storages to lowest minimum inventories corresponding to containment system, effective instrumentation, strengthening of inherent safety design and frequent auditing of documents and features as per HAZOP studies, transparent interactions with employees and community about the toxic chemicals, training and re-training of employees, off-site responders and community, regular enactment of emergency plans, harmonizing up of medical facilities etc.

Aimed at bringing down the risk and resultant consequences of chemical emergencies in the district, a Chemical Emergency Response Centre (CHEMREC) has been set up by the Factories and Boilers Department in association with the Industries Department, at Kochi during 2010. Equipped with latest communication network and active support of major industrial units, CHEMREC has facilities for field monitoring of chemical spills/releases into atmosphere, predicting its impact and apprising public on precautionary measures.

4 Conclusions

Highest levels of preparedness including scientific expertise at local, state and national level needed to be developed for management of chemical disasters and the special care to be taken in synchronizing District Disaster Management Plans & Industries Emergency Response Plans for better results. With a clear and definite disaster management policy, approach, strategies, plans and practices in place, it is possible to make Kerala state, in the long run, to be free of major disasters.

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Soil piping phenomenon: Examples from Idukki district, Kerala, India

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ABSTRACT

Subsurface erosion (piping and tunnel erosion) in non-karstic landscapes has for a long time been considered of little importance compared to sheet and gully erosion. In the case of soil piping erosion, linear voids are formed by concentrated flowing water in soils or unconsolidated deposits, which can cause collapse of the soil surface and formation of discontinuous gullies. Piping has been observed in both natural and anthropogenic landscapes, in a wide range of climatological, geomorphological and pedological settings. Pipe-flow in slopes provides a preferential runoff mechanism that bypasses the soil matrix, rapidly conveying water to the stream. Western Ghats also are not free from this natural hazard. During the year 2010, two places in Idukki District namely, Thattekkanni in Thodupuzha Taluk and Udayagiri in Udumbanchola Taluk experienced land subsidence due to soil piping. The present study envisages to the evaluation and comparison of the soil piping phenomenon of these two locations for framing the management and mitigation measures.

1 Introduction

Humid tropics produces the greatest amount of runoff (Fekete *et al.*, 2002), and has headwater basins noted for their flashy rainfallrunoff responses (Chappell *et al.*, 1999; Dykes & Thornes, 2000; Godsey *et al.*, 2004). Despite the extent of this hydroclimatic region, its hydrological significance and the current pace of disturbance, there are relatively few studies addressing rainfallrunoff processes within humid tropical hillslopes and basins (Bonell, 2004; Chappell *et al.*, 2007). These runoff responses are likely to be affected by the presence of *natural pipes* within the soil (Chappell, 2010). Piping has been observed in both natural and anthropogenic landscapes, in a wide range of climatological, geomorphological and pedological settings. Intensive research within experimental basins in temperate climates indicate that *natural soil piping* can be a dominant pathway for routing rainfall to rivers (Jones, 1994, 1997; Uchida *et al.*, 1999; Jones & Connelly, 2002). With much less experimental work on soil piping undertaken within the humid tropics (Bonell & Balek, 1993; Negishi *et al.*, 2007), their extent and hydrological role remains less clear. However, studies suggest that piping within humid tropical soils may have a significant impact on streamflow generation (Elsenbeer & Cassel, 1990; Chappell *et al.*, 1998; Elsenbeer & Vertessy, 2000; Chappell & Sherlock, 2005). Sankar (2005) first reported piping in Kerala from the Kannur district.

Earlier studies showed that preferential flow on hillslopes occur as a result of a self-organizing network of flow pathways that are associated with variously oriented macropores (Beven & Germann, 1982; Allaire *et al.*, 2002; Tsuboyama *et al.*, 1994, Sidle *et al.*, 1995 and Sidle *et al.*, 2001). The macropores themselves are not considered to be continuous throughout the soil profile or the hillslope. In some cases macropores might happen to join up directly with other macropores, but more likely the macropores are separated by some small distance. The connectivity between macropores is then conceived to result from highly permeable material that happens to be located between the endpoints of individual macropores. This high permeable material is then the 'node' that connects up the network of macropores. The high permeable material has been observed to be loose soil, decaying organic material, fractures in bedrock, or cleavage planes at lithographic boundaries. The 'nodes' are either open to flow or not open to flow depending on the moisture conditions. When they are open to flow then the macropore network becomes effective, while otherwise the network does not operate with respect to moving water around. In this way, macropores are not effective in subsurface flow during dry conditions, but during wet periods they do become effective and the degree of effectiveness increases with wetness (Figure 1).

Piping phenomenon has also been reported from glaciated terrain (Carey & Woo, 2000), loess (an aeolian sediment) deposited regions (Verachtert *et al.*, 2010), dam sites (Ballona & Grima, 2008; Aydan, 2010) and cultivated terraces (Watts, 1991). Piping normally occurs in sandy gravels. It is worth mentioning, however, that piping can also take place in dispersive soils. These soils are characterized by a dissolved sodium content of the pore water which is higher than the ordinary soil. Dispersive soils usually have a high exchangeable sodium content. They rapidly erode, forming tunnels by a process in which the clay particles go into suspension in slow moving water (colloidal erosion) and this type of piping is often called chemical piping (Ballona & Grima, 2008).

As far as the cultivated terraces are concerned, there are two main purposes behind the construction of agricultural terraces: (1) to allow crops to be planted on slopes which would otherwise be too steep for cultivation, and (2) to retain water after rainfall events, reducing run-off and hence increasing opportunity time for infiltration. Reducing run-off also decreases the chance of soil erosion by overland flow (Watts, 1991). Two hypotheses for pipe initiation in agricultural terraces can be recognized: (a) A saturated zone develops in the terrace front. The high pore water pressures in this zone physically dislocate particles from the terrace wall. Thus with this type of piping, the pipe starts, at the downslope end and works up into the terrace (Penman, 1986) and (b) Water flowing through pre-existing small channels in the soil enlarges these preferentially. Subsequently these macropores continue to grow because their greater size ensures that they are supplied with increasing volumes of water. Whatever the mechanism, it is clear that pipe initiation is the result of a process, which acts preferentially in particular zones of the terrace system.

Several studies within the humid tropics report the location of *pipe outlets* (with visible water-flow or signs that it has taken place recently). Most pipe outlets in the humid tropics are observed on the lower sections of hillslopes, close to ephemeral or perennial stream channels (Burton, 1964; Banerjee, 1972; Baillie, 1975; Walsh & Howells, 1988; Sayer, 2002; Sayer *et al.*, 2006; Putty & Prasad, 2000; Negishi *et al.*, 2007).

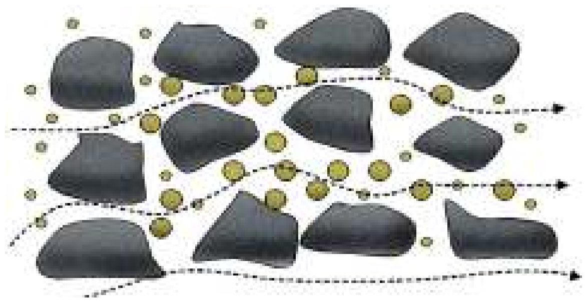

Figure 1. Piping phenomenon: Transport of fine soil amongst coarse particles (Ballona & Grima, 2008).

Subsurface erosion (piping and tunnel erosion) in non-karstic landscapes has for a long time been considered of little importance compared to sheet and gully erosion. In the case of soil piping erosion, linear voids are formed by concentrated flowing water in soils or unconsolidated deposits, which can cause collapse of the soil surface and formation of discontinuous gullies. Until recently it has been difficult to find and define soil pipe networks. This is because pipes are often only visible at stream banks or where the pipe roof has collapsed creating a surface opening or forming a gully. Therefore it is difficult to map soil pipe networks or to measure pipe diameters, depth and channel length below the surface. In some soils a change in surface vegetation may often indicate the presence of a pipe but this is only where pipes are very shallow features. Pipe locations are identified mainly by observation of collapse features, of water jets emerging from pipes and the sound of flowing water. However, these techniques do not give a detailed or complete picture of the subsurface network and can result in underestimates of the pipe density. Where pipes are several metres below the surface, they cannot be readily identified. The present study envisages to the evaluation and comparison of the soil piping phenomenon of these two locations for framing the management and mitigation measures. During the year 2010, two places in Idukki District, Kerala namely, Thattekkanni in Thodupuzha Taluk and Udayagiri in Udumbanchola Taluk experienced land subsidence due to soil piping. Generally, the pipe flow provides a preferential runoff mechanism that bypasses the soil matrix, rapidly conveying water to the adjoining stream/local base level of erosion.

2 Methodology

Evaluation of the piping phenomenon and its impacts at Udayagiri and Thattekkanni of Idukki district were done by field observations. Geomorphological analysis and topographical influence were brought in using GIS (Arc GIS) platform.

2.1 Regional settings and geomorphology

Idukki is one of the largest districts of Kerala with a vast area of 4479 km^2 and the rugged mountains and forests cover about 97% of the total area. The low land area is totally absent and midland (20–100 m msl) covers 4.5%, mid-upland (100–300 m) contributes 7.5%, upland (300–600 m) occupies 12.1%, the Western Ghat high range (600–1200 m) possesses 48.3% of the land area and the top Western Ghat high range (above 1200 m) has 24.5% of the land area. Because of the highly undulating topography, large area of the district is not suitable for scientific cultivation. Two types of soil are found in the district, i.e. forest loam of highland and laterite soil of other parts. The district enjoys a humid tropical climate and receives plenty of rain from both southwest monsoon and the northeast monsoon (annual rainfall varies from 250 cm to 425 cm). Apart from this, the district periodically receives cloud-bursting rainfall and thunder showers of vicious intensity.

Udayagiri. The region falls as part of the Precambrian crystalline terrain of the southern peninsular region. The region forms part of an undulating terrain, where the incidence was occurred on the northerly trending flank of a hill. Even though it is at the flank of a hill, substantial soil column has been developed in the area. The area is well cultivated with cash crops, especially, the cardamom plants. The area is characterised by the presence of lateritic soil with remarkable presence of clay and humus at the upper part. The soil column is unconformably lying over the hard crystalline rock. Even though the region has high drainage density and drainage frequency (Table 1) the phenomenon occurred area has low drainage density and drainage frequency clearly indicate that it has high intensity water infiltration and ground water recharge. Since the ground water follows the topography, the steeply sloping terrain (>30°) produces high hydraulic gradient in the region. People practices terraced cultivation in the region to prevent soil erosion.

Thattekkanni. The region also falls as part of the Precambrian crystalline terrain of the southern peninsular region. Thattekkanni region lies at the downslopes of the Meenozhinjaan Mudi, which has an elevation 887 m. A northwest–southeast trending valley demarcates the lower most position of the relief, which is occupied by the Periyar River. The upper region of the said hillock is still characterised by the presence of natural vegetation. Thattekkanni region forms part of a very undulating terrain, where the incidence was occurred on the northerly trending flank of the east–west trending Meenozhinjaan Mudi. Even though it is at the flank of a hill, substantial soil column (*ex-situ* nature) has been developed in the area. The soil column is unconformably lying over the hard crystalline rock. The soil column has very rich organic matter at the top, which overlies the mineral matter and very un-sorted grains. People practices terraced cultivation in the region to prevent soil erosion and it has been realised that the natural vegetation had been replaced by cash crops.

3 Results and discussion

Deep soil development (>7m) of the region has made a deep collapse and the presence of stream channel/wetland at the down-slopes has regulated the character of the ground water flow. Under such conditions, when an organic matter-rich soil layer overlies the hard crystalline rock and if there is substantial presence mineral substrate between these two unconformably occurring layers, water seeps through the soil and tends to transport the soil particles with it and as a result piping occurs. It generally occurs when the pore sizes are larger than the soil particles. This phenomenon occurs in sites composed of soils characterized by high water saturation capacity at the top layer. As a consequence, a change of water flow rate occurs and the piping process commences, giving rise to an outcrop of water seepage, where the finest soil particles are washed away with the water flow. The diameter and the depth of the resulting hole will enlarge in time.

The comparison of the salient features associated with the formation of soil pipes in Udayagiri and Thattekkanni and Udayagiri are given in Figure 2 to 7 and Table 1.

3.1 Udayagiri

It was reported that the region had received high intensity rainfall, that too within 48 hours, before the slumping occurred. It was assumed that the less channel development in the area has contributed high percolation rate to the ground water, resulting underground channel flow in the region. Deep soil development (>7.5 m) of the region has made a deep collapse and the presence of marshy area at the down-slopes (northern part of the incidence occurred properties) has regulated the character of the ground water flow. The region has low matrix hydraulic conductivity. As a result of this, the finest soil particles are washed away with the water flow by developing interconnected macropores. The diameter and the depth of the resulting hole enlarged with time. The anthropogenic activities have contributed significantly to the situation. Valley development and channel formation were hindered by man made activities. Apart from this, a stream channel, which is originating from the adjoining hill, has been diverted to the incident-witnessed property and the same is found disappearing there by draining downwards. It has been calculated that the same has contributed significantly to grimed situation. A large sink hole was developed in the property of Shri. Mathew Devasia, Nedumpurath (H), Prakash P O and another one at further downwards. Besides, a dug well located in the property of Shri. Josekutty, Moolayil (H), Prakash P O is also collapsed and the earth has moved down in another place in his property, which made his house unstable.

Table 1. Comparison of the different parameters associated with soil piping at Udayagiri and Thattekkanni.

Sl. No.	Item	Udayagiri	Thattekkanni
1	Taluk	Udumbanchola	Thodupuzha
2	Toposheet No.	58G/1	58B/16
3	Geo-position of subsidence	N9°50′18.5″, E77°03′19.2″	N10°00′01.7″, E76°53′18.9″
4	Elevation from MSL	962 m	163 m
5	Date of occurrence	18-08-2010	23-11-2010
6	No. of trenches formed	4	1
7	Trench diameter (outer)	2.8 m	0.80 m
8	Trench diameter (inner)	5.6 m	5.1 m
9	Trench depth	4.8 m	3.8 m
10	Rainfall intensity	High	High
11	Nature of topography	Undulating	Undulating
12	Slope	>30°	>30°
13	Aspect	North	North
14	Relief of the site	50 m	70 m
15	Drainage density (region)	2.39/km	2.9/km
16	Drainage frequency	4.8/km^2	4.84/km^2
17	Length of overland flow	0.175 km	0.172 km
18	Rock formation	Biotite gneiss	Hornblende biotite gneiss
19	Trend of the joints	Not available	N–S
20	Soil type	Lateritic	Lateritic
21	Nature of soil	Ex-situ, Humus rich	Ex-situ, Humus rich
22	Geo-position of exit point	N9°50′41.3″, E77°03′18.1″	N10°00′04.7″, E76°53′20.2″
23	Nearby influencing body	Wetland	Periyar river
24	Anthropogenic factors	Terracing, diversion of channel	Terracing, diversion of channel
25	Topographical expression, if any	Nil	Bended tree trunk
26	Visible Impact	1 house, 1 well became unstable	6 buildings became unstable

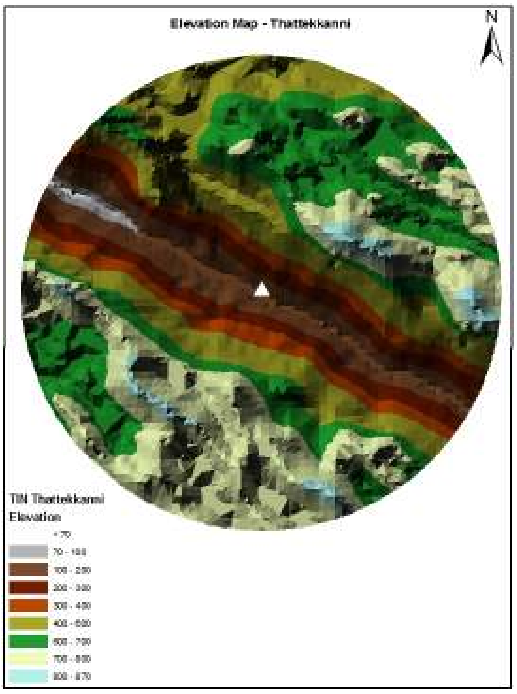

Figure 2. Elevation map – Thattekkanni.

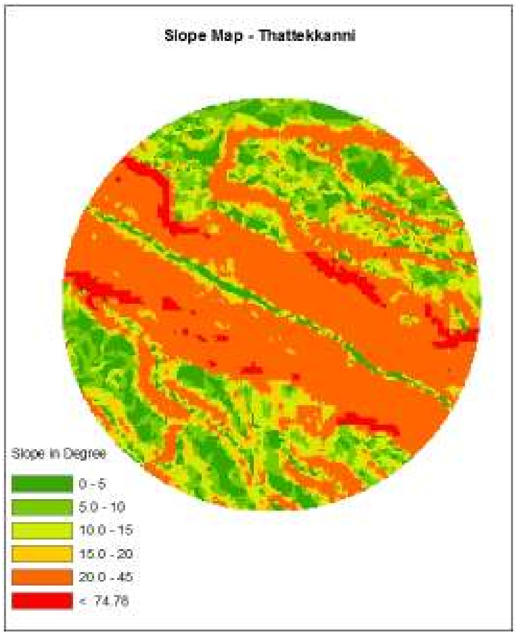

Figure 3. Slope map – Thattekkanni.

3.2 Thattekkanni

The site inspection revealed that the region had received high intensity rainfall before the slumping was occurred. The pipe flow provided a preferential runoff mechanism that bypasses the soil matrix, rapidly conveying water to the Periyar river. Runoff from hillslopes reaches the local base level of erosion through different path ways that affect both the timing and magnitude of responses to rainfall. Deep soil development (>7 m) of the region has made a deep collapse and the presence of Periyar river at the down-slopes (northern part of the incidence occurred property) has regulated the character of the ground water flow. Under such conditions, when an organic matter-rich soil layer overlying the hard crystalline rock and if there is substantial presence mineral substrate between these two unconformably occurring layers, water seeped through the soil and tended to transport the soil particles with it and as a result piping occurred. Valley development and channel formation were hindered by man made activities. It is assumed that the soil pipe has a general trend of NE–SW. It has been calculated that the regional secondary struc-

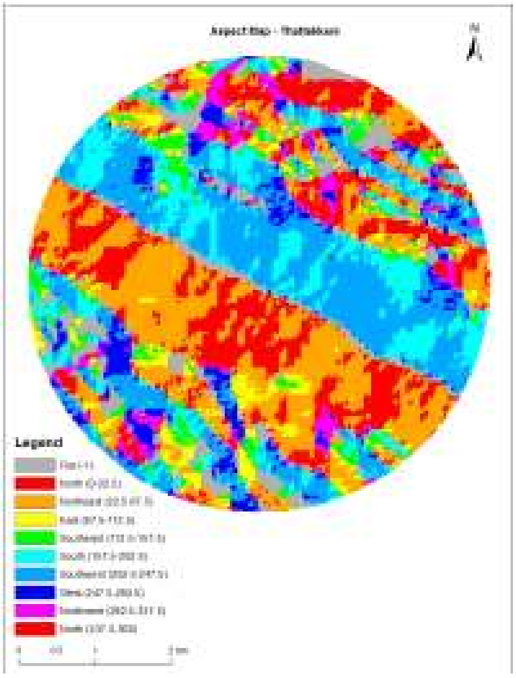

Figure 4. Aspect map – Thattekkanni.

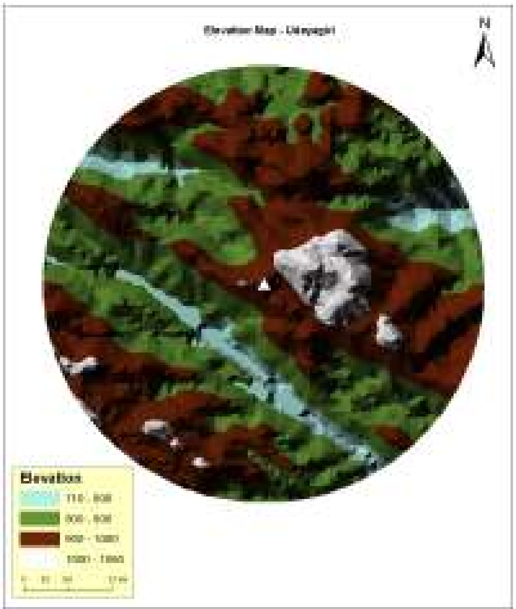

Figure 5. Elevation map – Udayagiri.

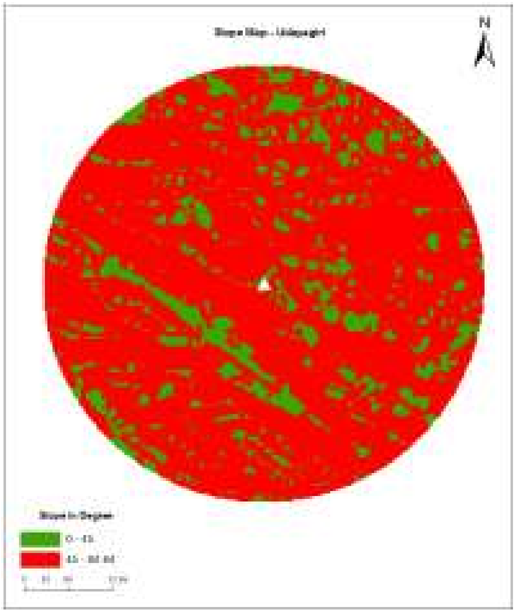

Figure 6. Slope map – Udayagiri.

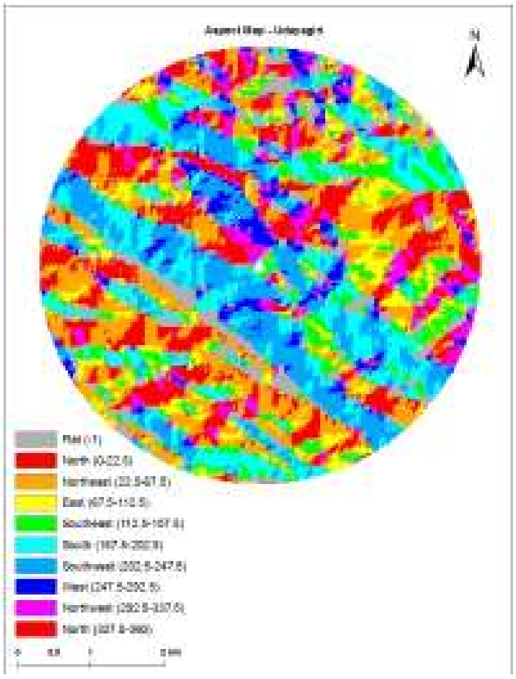

Figure 7. Aspect map – Udayagiri.

tures, i.e., the joints, which have a general trend of N–S, has contributed significantly to the situation. Heavy damages were occurred to an array of houses positioned just above the sink hole. The houses of (1) Shri. Johny Devasia, Koorappillil, and (2) Shri. Sinu Thekkumkattil have become very unstable due to hazard. The foundation of the house made by Shri. Mohanan, Cheriyankunnel (under EMS housing scheme) has also become unstable. The building of Thattekkanni post office and the house and the shop belong to Shri. George Koonathil are also found unstable.

3.3 Management strategies and suggestions

(1) It has been suggested to have an improved drainage channel development in the area.

(2) The conditions required for pipe initiation are low matrix hydraulic conductivities and the existence of macropores. Increased vegetation cover could help to prevent pipe initiation by intercepting rainfall and reducing the possibility of infiltration-excess overland flow becoming widespread on the terrace. It would do this in two ways: By increasing surface roughness and therefore slowing

flows, giving more opportunity for infiltration in less critical areas of the terrace (such as around the edges), and by increasing surface water detention, again preventing the water from reaching critical regions.

(3) Channel plugging and valley plugging should be avoided

(4) Diversion of channel, as seen in Udayagiri, to the incident occurred property should be avoided.

(5) A surface drainage along the southern side of Neriyamangalam—Idukki state high way shall be abandoned by improving the existing drainage facilities.

(6) Deep trenches along the slope direction will improve the draining of water during the monsoon/heavy downpour situations

(7) It has been suggested to have an in depth analysis using Ground Penetrating RADAR Device.

4 Conclusion

Piping has been observed in both natural and anthropogenic landscapes, in a wide range of climatological, geomorphological and pedological settings. Preferential flow on hill slopes takes place via macropores. These macropores are formed either by biological or mechanical processes. The macropores come in a wide range of sizes, directional orientation and continuity and this continuity of macropores increases as the degree of wetness of soil increases. Western Ghats are not free from piping phenomenon and the terraced cultivation practices significantly contribute to the grimed situation.

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Community health risk assessment on mercury contaminated fish consumption at Cochin backwaters

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ABSTRACT

Concern over potential human health risk of mercury associated with fish consumption has led many nations to issue consumption advisories and limits. Dietary survey over populations can provide essential information for exposure assessment, risk characterization and risk management. The current study focuses on human health risk assessment associated with the mercury contaminated fish consumption by human population living at the banks of Cochin backwaters. Fish samples were collected and analyzed for mercury content following standard methods. A random survey was conducted to evaluate the fish consumption rate and health status among the people. The mean methyl mercury (MHg) concentration in the edible parts of fishes was 0.67 mg/kg (wet weight) and the mean total mercury (THg) concentration was 1.03 mg/kg. The estimated fish consumption rate was 34g/day which is slightly higher than the national average of 30g/day. The hazard index calculated with the mean concentration of total mercury was 2.09, which indicates a high risk to human beings. The intake of methyl mercury calculated in the study was 2.85 microgram MHg/kg body weight/week which is much higher than the reference value suggested by FAO/WHO–JECFA, US, Canada and Japan. The health survey conducted on symptoms of mercury poisoning has indicated no adverse.

1 Introduction

Mercury contamination is a big concern in many countries due to its toxic effects on biotic and abiotic components of the ecosystem. It is one of the most toxic metals to the organisms at the top of the food chain (Guentzel *et al.*, 2007). The human health risk associated with mercury poisoning and elevated levels in marine and fresh water fish resulted in worldwide advisories for the consumption of fish and shell fish. The elevated level of mercury in fish are known to cause serious neurotoxic and genotoxic effects. The main source of exposure to mercury in human beings is the consumption of fish, shellfish and sea mammals (Clarkson *et al.*, 2003). This has led to many developed countries to issue fish consumption limits. India is one of the biggest consumers of mercury in the world and many of the Indian water bodies are severely polluted with mercury (Kalra, 2004). Elevated quantity of mercury in edible fishes is also reported from several places.

Earlier studies showed that the content of mercury and other heavy metals are high in the various environmental compartments of Cochin backwaters such as water, sediment and biota (Toms *et al.*, 2009; Mahesh *et al.*, 2010a, b; Ouseph *et al.*, 1992; Shylesh *et al.*, 2010). But no studies were conducted about the transfer of these contaminants to the human body and the risk posed to the local people. Human health risk assessment is the characterization of the potential adverse health effects associated with the human exposure to environmental hazards (Duah, 1998). Fish consumption information is essential for assessing the human health implications associated with the consumption of chemically contaminated fish (CEPA, 2001). Dietary survey over populations can provide essential information for exposure assessment, risk characterization and risk management. In this context the current study aims at gathering preliminary information about the fish consumption pattern of peoples at the banks of the Cochin back waters and assesses the current risk status associated with the consumption of mercury contaminated fish. A health assessment survey was also conducted as the part of the study to know about the visible symptoms of mercury poisoning among the peoples.

2 Study area

Cochin backwaters situated at the tip of the northern Vembanad lake is a tropical positive estuarine system extending between 9° 40′ and 10° 12′ N and 76° 10′ and 76° 30′ E with its northern boundary at Azheekode and southern boundary at Thanneermukham bund. This is the most important fish landing centre of Kerala. As an estuarine system the Cochin backwaters is a breeding ground for several fishes and prawns. Earlier studies (Ouseph, 1992; 1996) showed that mercury contamination was high in Vembanad backwaters mainly due to an industry which produced caustic soda using mercury cell process, which was replaced by membrane technology during 2004. But the studies done in elsewhere showed that the mercury concentration will persist in the sediment even if the source is stopped (Li *et al.*, 2009; Karunasagar *et al.*, 2006). Other major sources of mercury in the study area are urban waste, hospital waste, agricultural runoff and fossil fuel burning

3 Methodology

As the part of the study, fishes were collected directly from the fishermen and preserved till analysis. The muscle tissues were analysed for total mercury (THg) and methyl mercury (MHg) using CVAFS following standard methods (USEPA, 2001; Karunasagar *et al.*, 2006; Balaramakrishna *et al.*, 2005). For the dietary survey, questionnaire was designed according to standard survey methods (USEPA, 1998). The questions were prepared to gather information about (1) the personal data such as sex, age, body weight, occupation and community (2) fish consumption habits such as how long they are eating fish, approximate number of fish meals and approximate weight of fish consumed (3) types of fish consumed and parts of fish which they most prefer (4) visible symptoms of mercury poisoning by fish consumption. A total of 100 families were randomly selected from four locations (25 families from each location) of Cochin backwaters. The survey team members directly approached and interviewed one or more members of the family with the questionnaire. Housewives (ladies) were mostly preferred for the interview for getting more accurate information about the dietary habits and health status of the family members.

The average weight and fish consumption per day obtained from this survey was used for calculating the Hazard index. The hazard index (H) is the ratio between estimated dose (D) and Reference dose value (RfD) (Kannan *et al.*, 1998). The D was calculated using the formula

$$D = C \times \frac{I}{W} \times 1000,$$

where, 'I' is ingestion rate of fish by a person per day, 'W' is average body weight and C is the concentration of mercury in fish obtained in the study.

The intake of methyl mercury was calculated in the study using the formula

$$\frac{\text{Amount of fish ingested per week (g/week)} \times \text{Hg concentrations in the fish ingested (ppm or } \mu\text{g/g)}}{\text{Kilogram body weight (kgbw)}} = \mu\text{g MHg intake per kg bw/week.}$$

4 Results and discussions

The fishes selected in the present study are being used by common people along the coastal regions of Kerala, especially the fisherman community. All the fish samples were checked for total and methyl mercury accumulation in the muscle tissue. More than two samples were analyzed for each fish and the mean values are taken. THg varied from 0.093 to 2.321 mg/kg wet weight (Figure 1). The maximum MHg concentration (2.26mg/kg ww) observed for *Caranx affinis*. The mean THg observed was 1.03mg/kg wet weight whereas mean MHg concentration was 0.67 mg/kg ww.

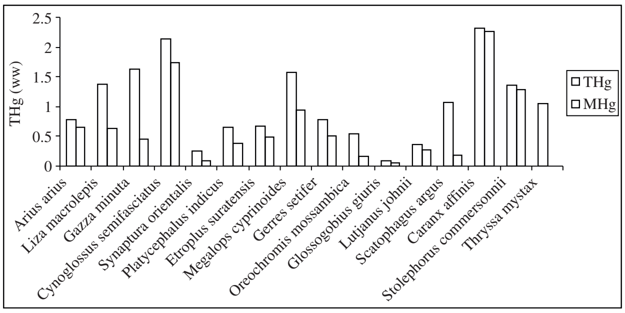

Figure 1. Total and methyl mercury in the muscle tissues of fishes.

Most of the people inhabit this area belong to fisherman community. The major source of income was from fish catch and related activities. Total number of people responded to this survey was 227 with an average weight of 56 kg and average age 44 years. Among them, 108 are males and 119 are females. The males interviewed were with an average weight of 61 kg and average age 43 years. The females were with average weight of 53 kg and average age of 45 years. The fish consumption rate observed from the survey was 34 g/day, which was calculated by excluding the weight of non-consumable parts. The fish consumption rate calculated in this study was slightly above the Indian average of 30 g/day. The Hazard Index (H) values based on average fish consumption (Indian) were calculated for ingestion of fish containing highest concentration of THg (2.41 mg/kg wet wt.) as well as mean concentration (1.03 mg/kg wet wt.). The 'H' value was 3.44 and 1.47 respectively for the highest and mean THg. The 'H' value calculated from the present survey results ($I = 34$g/day; $W = 56$ kg) are 4.9 and 2.09 respectively for highest and mean Hg content in fish. The 'H' values calculated based on both type fish consumption average (Indian and present survey) is >1. The H value being more than 1 indicates the high chance of occurrence of toxic effects in humans.

The exposure to MHg was calculated based on the survey results i.e. the average body weight (56 kg) and fish consumption rate (34 g/day). The calculated result was 2.85 μgMHg/kgbw/week and is higher than the MHg intake calculated (2.01 μg per kg bw/week) based on the average Indian consumption (30 g/day = 210 g/week) and the average body weight given by USEPA (70 kg). The mean MHg (0.67 μg/g wet wt.) observed in the present study was used for the calculation of MHg intake. This level of contamination exceeds the reference value suggested by FAO/WHO–JECFA, US, Canada and Japan. Reference level for methyl mercury is yet to be adopted in India. The results obtained (2.85 μgMHg/kgbw/week) was higher than the Joint FAO/WHO Expert Committee on Food Additives (JECFA) reference levels (1.6 μgMHg/kgbw/week) (UNEP, 2008). Further, the reference level obtained is also higher than the levels given by Canada (1.6 μgMHg/kgbw/week), Netherlands and United States (0.7 μgMHg/kgbw/week). While in Japan, Food Safety Commission (FSC) preferred slightly higher reference level (2 μgMHg/kgbw/week) when compared to others. The present study showed higher values while the calculation based on Indian average ingestion and USEPA reference body weight was almost same as of Japan FSC reference level. Therefore, as shown by the analysis of muscle tissues of selected fishes, the MHg intake is higher along the Cochin backwater region.

The findings of this study also points out that, as most of the brackish water fishes captured are being consumed by the urban population it is essential to carry out a detailed study in this regard with the urban fish eating population also. However, the good news is that the analysis of health status survey results indicates that there is no visible symptom of mercury poisoning noticed among the population surveyed in this study.

5 Conclusion

The fish samples from the Cochin backwater region contain significant amount of mercury. The risk analysis data shows the contamination level has a high potential for posing hazardous effects to the local community. But the health status survey did not give any significant evidence for the appearance of mercury poisoning symptoms. Even though high level of mercury contamination has been reported from several parts of India, we have not implemented any limits or standards for our fish consumption. This is because of the lack of proper monitoring and risk assessment studies at ecological and human health aspects. This study clearly shows the immediate necessity of management actions and regulations with respect to the mercury contamination and fish consumption at Cochin backwater region.

Acknowledgement

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A study to assess the effectiveness of awareness program on disaster preparedness among residents of selected apartment buildings in Bengaluru, South India

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ABSTRACT

Background and objectives: The role of communities and individual families in taking appropriate action to mitigate the impacts of disasters has been emphasized to the local government. The increased occurrence of small and medium scale disasters has resulted in the concept of Community Based Disaster Management which is a new approach to manage disasters through peoples participation. The incidents took place in Bengaluru over recent years and Government of Indias Disaster Risk Management Program and National Disaster Management Act influenced researcher to conduct A study to assess the effectiveness of awareness program on disaster preparedness among residents of selected apartment buildings in Bengaluru South. Objective of the study was to assess the existing knowledge, the existing safety measures regarding disaster preparedness, develop and conduct an awareness program, compare pre test and post scores and find out the association between level of knowledge on disaster preparedness and demographic variables

Method: A quasi experimental study was conducted using pre test and post test with control group research design. Purposive sampling technique was used to select 200 residents from each group. Data was collected by using structured interview schedule and observational checklist. The interview schedule a questionnaire comprised of three parts. Part I—Demographic Profile, Part II—Disaster and Part III—Disaster preparedness and Family Disaster Plan. Observation check list was employed for observation of existing safety measures in the selected apartments.

Results: In this study majority of respondents were in the age group of 19–28, gender males, being graduates and professionally they were engineers. Majority of the respondents did not experience any disasters in their life and obtained information on disasters through different mass media. More than 60 percent of respondents did not have any training on disaster management. In the pre test 66 percent and 78 percent of respondents had moderate knowledge regarding disaster and disaster preparedness in experimental and control group respectively. In this study there were inadequate safety measures available at the apartments to prevent and face the disasters both in experimental and control group. The mean percentage score in pre test of control group was 60.05 percent against 59.15 percent of mean scores in experimental group.

After awareness programme, in the post test the mean scores of experimental group was 77.8 percent. The mean difference in the pre-test and post-test scores in the experimental group was 18.65 percent which was statistically significant, however difference between pre-test and post-test in control group was 1.7 percent which was not statistically significant. Only in experimental group there was significant association between information and knowledge.
Interpretation and Conclusion: Majority of the participants are between the age group of 19–28 years, graduates and professionally engineers. There were inadequate safety measures available at the apartments to prevent and face the disasters. In the post test score of experimental group there was 18.65 percent mean enhancement observed and there was significant increase in knowledge scores ($t = 2.715*, p < 0.05$). There was no significant change observed in control group. Hence awareness program on disaster preparedness was effective in imparting knowledge.

1 Introduction

The Indian subcontinent is among the worlds most disaster prone areas as about 54 percent of Indian land areas are vulnerable to earthquakes, 8 percent vulnerable to cyclones and more than 5 percent vulnerable to floods, 68 percent of land vulnerable to drought and it is observed that more people die in fires than all natural disasters every year. Combined with these estimations can we lay back and pronounce that we are safe? No. Disasters have shown their abilities to strike anywhere and at anytime. A family attended morning mass at Vellankani shrine and then went to a roadside eatery only to be swallowed by the sea. Overnight, five out of six Shakat and Ruksana's children were victims of bomb blast in the India Pakistan Samjhauta express. Could a tragedy of this nature and dimension have been avoided? Could we have saved most of the lives that have now been lost? Could we have forecast the scenario and been better prepared? Well these are the questions that we will have to answer if we are to make this world a safer place. When we engage in pre-disaster planning, we anticipate that, a disaster is likely to occur in our state at some future time. We wont know what that disaster will be, so we try to organize our response operations to provide maximum readiness for many possible hazards. Getting prepared for an emergency assignment is not so easy. The role of communities and individual families in taking appropriate action to mitigate the impacts of disasters has been emphasized to the local government. The increased occurrence of small and medium scale disasters has resulted in the concept of Community Based Disaster Management which is a new approach to manage disasters through peoples participation. Community Based Disaster Management is now becoming an integral part of any local or national disaster management planning.

2 Need for the study

Losses from disasters have increased dramatically over the past few decades. The loss of population and property is always on the rise. This is because of changes in pattern of hazard occurrence and from increased vulnerability of a growing population. With greater pressure to exploit marginal lands and accommodate more people in urban areas, the potential for future disasters continues to expand. Bulk of the inhabitants of urban area including Bengaluru resides in apartment building. It is great to see a cosmopolitan culture in one apartment (Shaheed, 2005). Once known as pensioners paradise Bengaluru was also identified by its cosmopolitan and peace loving nature. Does the scenario remain same today? Are they safe residing in apartment? Past incidents lead us to think otherwise.

On 12th September 1983, an eight-floors building under construction, located at Subedar Chatram road adjacent to Kapali theatre collapsed and at least 120 were killed and scores injured. On 26th July 2007 two persons including an 18 month old baby were killed and three others injured when section of a building at Ejipura in Bengaluru collapsed. At leastă7 people were killed and 14 others injured when a building collapsed in Bangalore late night on December 12 2011. On 23rd October 2008 four persons were injured and another 100 construction workers had a providential escape when a part of a 15-storeyed concrete structure under construction of the Prestige group crashed at Whitefield. Even Bengaluru that was considered safe experienced the quake measuring 4.5 on the Richter scale. After Lathur, its now a confirmed fact that Southern Peninsula is no longer safe from quakes. Out of 82,810 emergencies attended by Karnataka Fire Service in the year 2006, most of the calls were from Bengaluru city. From January 2005 to May 2005 there have been 642 fire accidents in Bengaluru, of these 42 were caused by LPG cylinder leakage and 124 by electric shock circuits. Bengaluru was witness to quite a few tragedies related to electricity in the last few years. Among those, Carlton towers fire tragedy, Bangalore Central fire accident, Gokuldas Export Ltd's gowdown fire accident are few alarming incindents. Government of Indias Disaster Risk Management Program (a community-based initiative for preventing and handling disasters through participation of communities and the local government), the thematic focus of Government of Indias Disaster Risk

Management Program (generating awareness, education, training and capacity development for mitigation leading to better preparation in terms of disaster risk management and recovery at community levels) and Incidents mentioned above that took place in Bengaluru over recent years influenced the researcher to study this topic. With this emerging scenario researcher would like to contribute his humble service to the community through this study.

(1) To assess the existing knowledge regarding disaster preparedness among residents of the apartment buildings in control group and experimental group.

(2) To assess the safety measures available in the apartment buildings.

(3) To develop and conduct an awareness program on disaster preparedness to experimental group.

(4) To compare pre-test and post-test scores regarding disaster preparedness among the residents of apartment buildings in control and experimental group.

(5) To find out the association between level of knowledge on disaster preparedness and demographic variables.

Operational definitions

In this study **disaster** refers to the fire accidents and building collapses in the apartment building, **Disaster preparedness** refers to those measures taken before a fire accident and collapse of building, which are aimed at minimizing the loss of life, disruption of critical services and damage when disaster occurs, **Awareness program** refers to education provided to the residents of apartment building to take preventive measures in wake of fire and building collapse and minimize risk during disaster. **Awareness program** involves fire safety, safety measures on building collapse, how to react when there is a fire or building collapse and family disaster preparedness. Using Pamphlet, Brochures and Posters, Apartment building refers to the apartments which are more than three storey and having houses between seventy to hundred and **residents** refers to people staying in selected apartment buildings.

Methodology

Research approach & research design

In view of the nature of the problem under the study and to accomplish the objectives of the study Quasi experimental approach is adopted.

Setting: This study has been conducted at the two apartments of the wards of Benguluru South Srinivasa Nagara and Jayanagara 9th block. In this study population refers to residents of apartment building who are above 19 years of age.

Sample and Sampling Technique: Samples for the present study are residents of selected apartment A and apartment B at Srinivasa Nagar and Jayanagara 9th Block. The sample size of this study is 200 residents of apartment buildings. 100 each for experimental and control group. In this study purposive sampling is adopted. Researcher had a plan of adopting Simple Randomization but due to unavailability of list of apartments from Bengaluru Bruhut Mahanagara Palike and to survey the apartment at different wards is time consuming one hence purposive sampling was adopted. A structured interview schedule was selected to assess the knowledge regarding disaster and disaster preparedness. Observational method was adapted to assess the existing safety measures at selected apartment building. Due to non availability of any relevant standardized research tool, the researcher developed a tool, based on the study objectives. After extensive and systematic review of literature and discussion with the experts, the investigator had developed the structured interview Schedule and observational checklist.

Description of the tool: After a thorough review of literature related to the topic a structured interview schedule and observational checklist was developed. The structured interview schedule consisted of 3 parts: part-1 includes the demographic data, part-2 consists of knowledge questions regarding disaster and part-3 consists of knowledge regarding disaster preparedness and family disaster preparedness. Part 2 & 3 consists of 40 items, there were 30 statements covering knowledge questions with 4 options out of which one is the correct response. For every correct response a score of 'one' and for every wrong response a 'zero' was awarded. There were 10 more alternate response items with two options, they are 'Yes' or 'No' out of which 'Yes' was considered as correct response. For every correct response a score of 'one' and for every wrong response a 'zero' was awarded. The knowledge level of respondents were classified as : Adequate 31–40 points (76 percent 100 percent), Moderate 21–30 points (51 percent to 15 percent), Inadequate 0–20 points (0 percent to 50 percent). Observational checklist was derived from National Building Code Part IV and suggestions from the experts to assess the existing safety measures at apartment building. This observational checklist was containing 12 items with the option of 'Yes' or 'No' answers and 'Yes' answers indicates availability of safety measure required at apartment. 'No' indicates non availability. Each 'Yes' was carrying a score of 'One' and each 'No' was carrying 'Zero'. Absence of any one of the safety measures mentioned in observational checklist is considered to be inadequate.

Testing of the instruments: Content Validity, Language Validity, Pretesting of tool was done and the stability of the tool was done by test retest method using Split half technique by Spearman Brown prophecy formula. The reliability obtained was $r' = 0.72$ indicating the tool is stable and reliable. The reliability coefficient of internal consistency was computed by using Chronbach Alpha, with manual and Statistical Package for Social Science (SPSS). The reliability obtained for knowledge tool was $\alpha = 0.6061$ hence, the tool was found to be internally consistent and reliable for the study.

Table 1. Schematic representation of research design.

Residents	Pre test	Treatment	Post test
Experimental group	Knowledge test (O_1)	Awareness Program (X)	Knowledge test (O_2)
Control group	Knowledge test (O_3)	No interventions	Knowledge test (O_4)

Development of the awareness program: Awareness program was developed with the extensive literature review and suggestions from experts. Awareness program is composed of three different aids they are Brochure on Disaster Management, Pamphlet on Family Disaster Preparedness and Posters on Disasters Preparedness.

Steps in developing awareness program:

- Preparation of awareness plan.
- Preparation of first draft of Brochure, Pamphlet and Posters.
- Content validity of awareness plan.
- Translation of Brochure, Pamphlet and Posters in to English and retranslation.
- Pretesting of the Pamphlet, Brochure and Posters.
- Printing of Brochures, Pamphlets and Posters.

The content selected was organized in the Brochure, Pamphlet and Posters as below.

Brochure

Title: Disaster Management — Must Know

- Define disaster.
- Types of disaster.
- Impacts of disaster.
- Management of disaster.
- Magnitude of disasters global, national, state and local level.
- Causes of fire.
- Measure to be taken during fire.
- Prevention of fire.
- Cause for building collapse.
- Measures to be taken during building collapse.
- Emergency contact number.

Pamphlet:

- Title: Family Disaster Preparedness.
- Make a plan.
- Build a kit.
- Get trained.
- Volunteer.
- Give blood.

Posters: There were eight posters developed under following headings.

- Disaster and vulnerability at apartment building.
- Disaster management.
- What do you know about fire?
- What to do in case of fire?
- Fire extinguishers.
- Preventions and precautions of fire.
- Building collapse.
- General tips.

Pilot study: Pilot study was conducted in apartment A and apartment B in Bengaluru North. Sampling technique adapted was purposive sampling rather than randomization because of time limitation and unavailability of list of apartments from Bruhut Bengaluru Mahanagara Palike.

Procedure for data collection: The Chairman's of Apartment Owners association were approached and permission was obtained from respective apartment's owner association to conduct a study at their apartment. The data was collected between 01/12/08 to 20/12/08. Investigator utilized the purposive sampling technique to select the study respondents. Investigator personally visited each respondent, introduced himself to the samples and explained the purpose of the study and ascertained the willingness of the participants and the respondents were assured anonymity and confidentiality of the information provided by them. Data was collected with the help of structured interview schedule and observational method.

3 Results

3.1 Demographical variables of residents of apartment building

In this study majority of respondents were in the age group of 19–28 that is 48 percent each in experimental and control group. So majority of respondents were in the early adulthood. Majority of the respondents were males, males were contributing 78 percent and 64 percent in experimental group and control group respectively. In relation to educational status none of the respondents were illiterate and interesting finding is majority of them were graduates and post graduates. In experimental group 52 percent and in control group 58 percent of respondents were graduates. Second highest

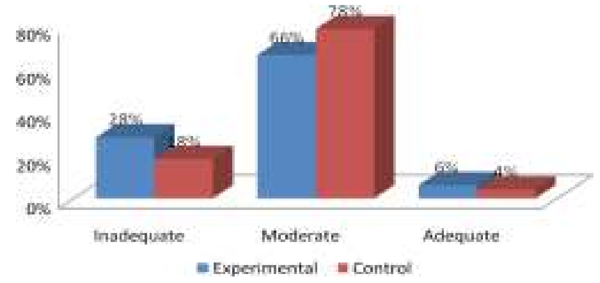

Figure 1. Distribution of knowledge scores on disaster preparedness in experimental and control group.

was post graduates 44 percent and 36 percent of respondents were postgraduates in experimental and control group respectively. In relation to their profession majority of them are engineers, there were 66 percent of respondents were engineers in experimental group and in control group 50 percent respondents who were engineers. Only 6 percent and 2 percent health professionals were found in experimental and control group respectively. In relation to experience 16 percent of respondents had experienced one or a other type of disaster in their life and out of them 80 percent of these experienced people have been exposed to man made disaster i.e. bomb blast, building fire, stampede at Kumbhmela and 20 percent of these people experienced natural disaster i.e. flood. In control group 22 percent of respondents have experienced disasters in their life. Again here in this control group 18 percent of respondents were exposed to man made disaster and 4 percent were exposed to natural disasters. In relation to information obtained from mass media more than half of the respondents were obtained information on disaster and disaster management through mass media i.e. 50 percent and 52 percent respondents in experimental and control group respectively. In relation to training on disaster management 36 percent and 10 percent of respondents from experimental and control group respectively had training on disaster management. The form of training they received was fire drill organized at their office.

3.2 Existing knowledge regarding disaster preparedness among the residents of apartment building

Majority of the respondents had moderate knowledge on disaster and disaster preparedness. In experimental group majority of the respondents had moderate knowledge accounting for about 66 percent. 28 percent of them had inadequate knowledge and only 6 percent of the respondents had adequate knowledge. Whereas in control group 78 percent of respondents had moderate knowledge, only 4 percent had adequate knowledge and remaining 18 percent had inadequate knowledge.

This is consistent with the study conducted on risk assessment and information-seeking on the preparedness awareness, knowledge, and attitudes of the general public in a rural setting using a series of focus groups. In this focus group interview certain group reported a lack of familiarity with preparedness terminology, as well as different ideas about trusted sources and agencies responsible for providing preparedness training or information.

3.3 Existing safety measures at apartment buildings

In this study both the apartments selected for study had inadequate safety measures. There were 50 percent of the apartments building that had installed smoke alarm remaining 50 percent did not. It was observed that fire escape route; public address system was blocked with obstacles in experimental group where as in control group smoke alarm, public address system was not found.

3.4 Administration of awareness program

Awareness program was conducted on disaster preparedness and family disaster plan using Brochures, Pamphlets and Posters. The information on awareness program i.e. venue, time was told to the participants during the time of pre test interview. Publicity was given on awareness program by tying two banners at apartment premises providing information on event, venue and, time. Children and spectators who witnessed the awareness program were motivated to bring their parents and neighbours respectively. The response to the awareness program was good. Along with participants there were many other residents who were residing at that apartment who got benefited by this awareness program. Feedback written in the suggestion book was very positive and majority of them reached to an agreement that ‘Failing to plan is the planning to fail’. Many felt that the topic was very relevant to the present context. For majority of spectators family disaster preparedness was a new concept. They assured that they will contact either Karnataka Red Cross Society, or Civil Defence Cell Bengaluru to get trained in disaster management so as to prepare themselves during times of disasters.

3.5 Evaluation of awareness program

In experiment group after awareness program there were 90 percent of residents who had adequate knowledge against the 6 percent during pre test. Remaining ten percent had moderate knowledge and no one had inadequate knowledge during post test. In control group only 16 percent of residents had adequate knowledge while answering to post test which was against the 4 percent during pre test. Hence there was noticeable enhancement of knowledge after awareness program among experimental group. The overall pre test and post test mean knowledge in experimental group was found to be 59.15 percent and 77.8 percent indicating the enhancement of knowledge as 18.65 percent which was statistically significant ($t = 2.715*, p < 0.05$). The overall pre test and post test mean knowledge in control group was found to be 60.05 percent and 61.75 percent indicating the enhancement of knowledge of 1.7 percent which was not statistically significant ($t = 0.0002, p > 0.05$). The overall pre test mean score of knowledge score between experimental and control group was found to be 59.15 percent and 60.05 percent indicating the mild difference in the mean knowledge score as 0.9 percent which proved statistically not significant ($t = 0.6357, p > 0.05$). The overall post test mean knowledge score between experimental and control group was found to be 77.8 percent and 61.75 percent indicating the difference in the mean knowledge score as 16.05 percent which proved statistically significant ($t = 0.6357*, p > 0.05$). Hence it is indicating that awareness program was instrumental in increasing knowledge regarding disaster preparedness among respondents of experimental group hence it is that awareness program has increased the level of knowledge of experimental group. Therefore, awareness program on disaster preparedness was effective on enhancement of knowledge. These findings are also supporting a study conducted on the prevalence of firework injury for 10 years which concluded that aggressive awareness campaigns by government and non-government organizations was the main cause for decreased fire work injuries in India. The results are also in agreement with study which was conducted to evaluate Community-Based Fire Preparedness Programmes. In this project, participants in a novel program of the Victorian Community Fire Authority, Community Fireguard, were surveyed, based on a Pre/Post design. For comparisons, a control group not exposed to the campaign was included. The results available were very encouraging for Community Fire Authorities new approach to bushfire preparedness of residents.

3.6 Association between demographic variables and knowledge regarding disaster preparedness

In control group there was no significant association between knowledge and other demographic variables i.e. age, sex, education, occupation, training and experience. There was only significant association found between information and knowledge on disaster and disaster preparedness. There was no significant association between post test knowledge regarding disaster preparedness and any of the demographical variables i.e. age, sex, education, occupation, experience, training and information in control group.

4 Conclusions

In this study majority of respondents were in the age group of 19–28 and males, most of them were graduates and by profession they were engineers. Majority of the respondents did not experience any disasters in their life and more than 50 percent of the respondents obtained information on disasters through different mass media. More than 60 percent of respondents did not have any training on disaster management. Majority of respondents had moderate knowledge regarding disaster preparedness that is 66 percent and 78 percent of respondents in experimental and control group respectively during pre test. In this study there are inadequate safety measures available at the apartments to prevent and face the disasters like fire and building collapse. This study indicating that awareness program was instrumental in increasing knowledge regarding disaster preparedness among respondents of experimental group hence it is concluded that awareness program on disaster preparedness is effective. There was a significant association between information and knowledge on disaster and disaster preparedness in experimental group.

Implication of the study: Present study would indirectly help us to understand the level of knowledge on disaster preparedness among the residents of apartment building. Helpful for NGOs, public administrators, civil defense cell etc to plan the educational activities based on the study outcomes, anticipate the needs and implement the need based interventions. Lessons regarding disasters and disaster management should find place in regular general curriculum in primary and secondary level education. There is an increased need for awareness program regarding disaster preparedness at local level and different working set up specially industries, schools and multi-storied buildings etc.

In regards to the issue of engaging and empowering communities for sustainable disaster risk management, followings are the major measures to be implemented:

(1) Community empowerment and Information Education and Communications help to achieve sustainability in Community Based Disaster Management.

(2) A holistic secure-livelihood approach enhances sustainability.

(3) Community based action plans and training improves community's problem solving skills.

(4) For every training or awareness campaign family should be considered as a basic unit.

(5) Because disasters are unpredictable, it is important update the public regarding disaster risk management.

(6) Transparency of activities and dissemination of knowledge and information encourage people's participation in activities.

(7) 'What is accepted by the community' is more important than 'what is necessary' and community acceptance is the big mile stone in achieving community participation.

(8) Strict implications of National Building Code and regular mock drills are very essential and should make it mandatory in all types of building.

(9) A similar study can be replicated on a large sample for wider generalization and NGO/Civil Defense Cell etc can work on public awareness on disaster management.

(10) A similar study can be done in urban slums.

(11) A longitudinal study may be undertaken to assess the effectiveness of intensive awareness program on disaster preparedness.

(12) If there are any disasters at the same apartments study can be undertaken to assess the effectiveness of awareness program on practice of disaster preparedness.

(13) Follow up study can be done to assess practice of the family disaster plan at these apartments.

(14) A descriptive and co relative study can be undertaken to assess the knowledge and practice of disaster preparedness among the residents of apartment building on a large sample.

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Bimodal fore-arc elastic thickness on Sumatra-Java subduction zones: implication for inter-seismic coupling and occurrence of large magnitude earthquakes

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effective elastic thickness (T_e)

ABSTRACT

The effective elastic thickness (T_e) is a useful tool to parameterize the intra and interplate crustal deformations in an active plate margin. We use Bouguer admittance (Morlet isostatic response function) technique over the Indonesian active plate margin, one of the most active plate margins in the globe as evidenced from its vast record of historic seismicity and tsunami events. Seven oceanic windows of size 990×990 km^2 have been taken over the Andaman, Sumatra and Java subduction zones to estimate the spatial T_e variations in the subducting as well as overriding plates. The results obtained show bimodal T_e distributions along the fore-arc zones of the Sumatra ($T_e < 20$ km) and Java ($T_e \sim 20$ 40 km). The low fore-arc T_e (LFT_e) obtained for Sumatra appears to correlate well with the zones of historical-high magnitude seismicity. In a stark contrast, the Java fore-arc exhibits high strength (T_e 40 km) and is associated with less frequent low magnitude earthquake events. The spatial fore-arc T_e variation and occurrence of shallow seismicity have been correlated to the factors such as obliquity and rate of plate convergence, nature of interseismic coupling and the amount of serpentinization at the down-dip limit. Thus we could suggest a strong and wide interseismic coupling for Sumatra between the subducting and overriding plates, and deeper mantle contributing to low strength, shallow focus—high magnitude seismicity and vice versa for Java, leading to their seismogenic zonation.

1 Introduction

Mechanical strength of the lithosphere describes its stability under deforming forces (Burov & Diament, 1995; Watts & Burov, 2003; Audet & Mareschal, 2004). The effective elastic thickness (T_e) parameterizes a numerical expression for the strength of the plate (Watts, 2001). Continental lithospheres are exhibiting a high range of T_e generally with a bimodal distribution of average minimum range of 20 km and an average maximum of 80 km. They depend primarily on the factors such as composition, geometry, thermal structure and state of stress of the lithosphere due to external forces (Burov & Diament, 1995). T_e variation of the oceanic plate is generally attributed to its thermal age, and hence T_e increases with the age of the oceanic lithosphere.

Subduction zones are unique among all the active plate margins for their college of deviatoric tectonic forces and dynamics. Recent studies are indicating that within the subduction zone, fore-arc segment is the potential site for large magnitude and frequent earthquakes due to the frictional forces at the interface between the subducting and overriding crustal segments

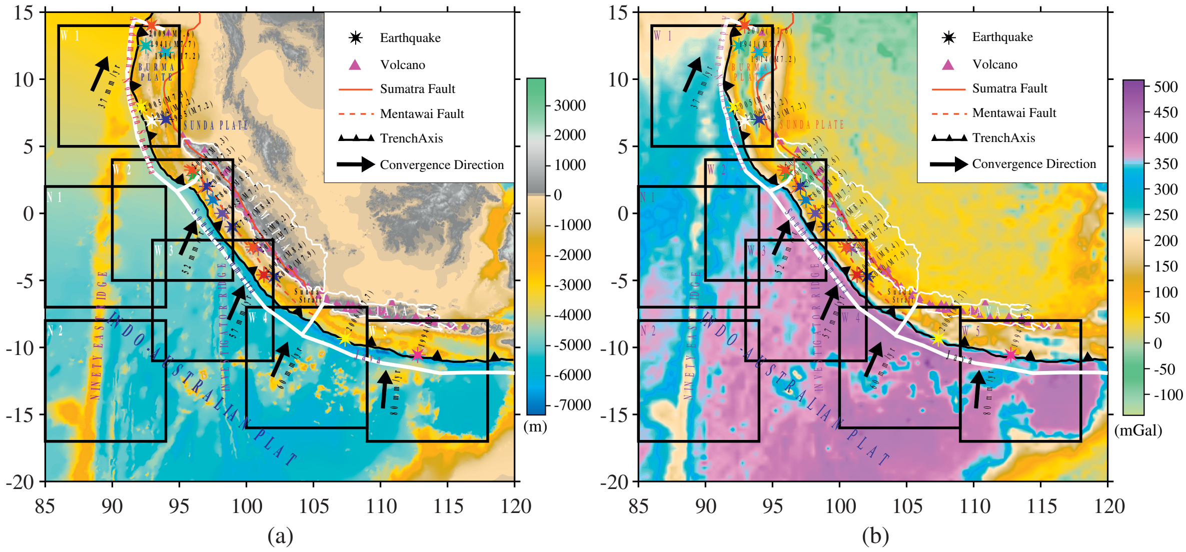

Figure 1. (a) Tectonic setting of the Andaman–Sumatra–Java subduction Zone, superimposed on GEBCO bathymetry and (b) Bouguer gravity map, exhibiting the major morphological features on the Indo-Australian (subducting) plate and the Sunda–Burma (overriding) plate; such as Ninety–East Ridge (NER), Investigator Fracture Zone, trench axis, Sumatra Fault, Mentawai Fault, Sumatra–Java islands etc. The region between the trench axis and the Island chain is the fore-arc segment on which epicenters of several recent and historic megathrust earthquake events ($M > 7$; 1797–2007) have been plotted (stars). The thick white line is demarcating the subduction zone segments include Andaman–Northern Sumatra, Southern Sumatra, and Java, based on their seismicity and morpho tectonic trends. The thin white line is demarcating the coastal boundaries of Sumatra and Java islands. Windows (W1, W2, W3, W4, W5, N1 and N2) are representing the selected areas for the Te estimation.

(Seno, 2005; Grevemeyer & Tiwari, 2006; Konca *et al.*, 2008; Chileh *et al.*, 2008). This frictional interface is known as the interseismic coupling zone, which is assumed to be an important factor to determine the magnitude of the shallow earthquakes. A classical example of a subduction system in the north eastern Indian Ocean includes the Andaman-Sumatra and java regions.

1.1 Geodynamic setting

The Indonesian continental margin (Figures 1a and 1b) is a prototype of a complex subduction zone lying at the boundary of the Indo–Australian plate (IAP). The subduction is resumed to commence from early Cretaceous (Scotese *et al.*, 1988) extending from Eastern Himalayan syntaxes to Sunda arc. The subduction system is composed of the down going Indo-Australian slab beneath the Sunda and Burma tectonic plates (Curray *et al.*, 1979; Kamesh Raju *et al.*, 2007; Curray, 2005). The subduction of oceanic crust of different ages and with different rates (Krishna *et al.*, 1995; Krishna *et al.*, 1999; Gopala Rao *et al.*, 1997; Kamesh Raju *et al.*, 2007) resulted in varying slab geometry in the Sumatra-Java regions. The major features formed due to this process are an accretionary wedge, the outer arc forming the backstop and fore-arc basins (Samuel & Harbury, 1997; Schliuter *et al.*, 2002). Figure 1 shows the subduction zone segments comprising Burma plate (Andaman, Nicobar Islands and offshore of Northern Sumatra), Sunda plate (Southern Sumatra and Java).

The other prominent structures on the subducting plates adjacent to the subduction zone are the aseismic ridge segments such as Ninety-east Ridge (NER), Investigator Ridge, etc. The NER is one of the longest linear features on earth, extending from 31° S to 17° N following the 90° E meridian, trending NNE-SSW, and is lying at the close proximity of the Andaman-Sumatra subduction zone. Gravity estimations over NER shows a slight positive free-air anomaly, concluded that the ridge topographic load is compensated by a deep root of Moho deflection into the mantle (Krishna *et al.*, 2001). The studies indicate that the ridge subduction complexities have not yet initiated for the NER, but may be advancing towards an initial stage of convergence processes (Subrahmaniam *et al.*, 2008).The direction and rate of subduction of Indo–Australian plate along the trench is quite different from Sumatra to Java (Lasitha *et al.*, 2006; Grevemeyer & Tiwari, 2006; Irsyam, 2008). Normal subduction of an old lithosphere (∼130 Myr) at a fast convergence rate (∼80 mm/yr) is the characteristic of Java subduction zone. On the other hand, in Sumatra, a comparatively young lithosphere (∼53 Myr) (Krishna *et al.*, 1995; Simoes *et al.*, 2004) is subducting in an oblique manner at a slow convergence rate (∼52–60 mm/yr) (Lasitha *et al.*, 2006). Oblique subduction lead to the procreation of the two strike slip fault components in the Sumatra margin, known as Sumatra and Mentawai fault segments (Malod, 1995). The nature of seismicity also differs from Sumatra to Java. Sumatra fore-arc is characterized by a vast record of great historic earthquakes like that of 1797 (M8.4), 1861 (M8.5), 2004 (M9.3), 2005 (M8.6), 2007 (M8.4) etc (Konka *et al.*, 2008; Chlieh *et al.*, 2008; Grevemeyer & Tiwari, 2006; http://earthquake.usgs.gov/regional/neic). While Java fore-arc is so far less seismically disturbed. Great earthquakes ($M > 8$) and active, deep lying fault segments are rare in this region.

We used the more appropriate Banks model (Banks *et al.*, 1977) in our present analysis using Bouguer Admittance method along the Indian Ocean subduction zone and adjoining Ninetyeast ridge (NER) to test whether rigidity structure in the study area had a causal relationship with segmentation of seismogenic zone. Our analysis will focus on a correlation between the spatial variations of T_e and the occurrence of large magnitude earthquakes in the fore-arc zone.

2 Data analysis

The analysis requires bathymetry data, Bouguer gravity anomaly data and crustal thickness data. The bathymetry data obtained from GEBCO Digital 1 minute bathymetry data (NOAA, 2003), which is converted to equivalent topography. The equivalent topography is the height or depth the crust will assume in the absence of ice or water present and under isostatic conditions this is (Daly *et al.*, 2004) given by

$$h(x) = \frac{\rho_c - \rho_w}{\rho_c} \tag{1}$$

where $h(x)$ is the equivalent topography, d is the bathymetry (in meters), ρ_c and ρ_w are the mean crustal density (2800 kgm^{-3}) and the water density (1030 kgm^{-3}) respectively.

We have used the free-air gravity data derived from the Global marine gravity field from ERS-1 and GEOSAT geodetic mission altimetry of Anderson & Knudsen (1998) and Anderson *et al.*(2008). The free-air gravity anomaly data, ΔG_f is converted to Bouguer gravity anomaly, ΔG_b using the slab formula and a surface rock/ water density contrast of $\Delta\rho = 1670$ kgm^{-3}, applied to the bathymetry data:

$$\Delta G_b = \Delta G_f + 2\pi\Delta\rho GH \tag{2}$$

where H is the bathymetry (in meters) and G is the gravitational constant.

The crustal thickness data used is from the CRUST 2 model (Bassin *et al.*, 2000). The other restrictive conditions in the implementation of Bouguer admittance is overcome by analyzing the study area in window sizes (990 × 990 km^2) which is several times the flexural wavelength of the lithosphere and the data samples the same tectonic province and thus ensured that integrated strength corresponding to the tectonic province. Figure 1a and b shows the tectonic setting plotted on the bathymetry and the Bouguer anomaly map respectively.

3 Methodology

The fan wavelet (Kirby & Swain, 2004) is the superposition of 2D Morlet wavelets arranged in fan shaped geometry. The coherence or admittance is obtained by estimating the cospectra and cross spectra of the gravity and topography data. Instead of Fourier transform, continuous wavelet transform (CWT) is employed to compute the local power spectra.

The CWT of a 2D spatially distributed signal $g(x)$ is estimated by taking the convolution of the signal with the complex conjugate of a wavelet:

$$\tilde{g}(s, \boldsymbol{x}, \theta) = \boldsymbol{F}^{-1}\{\hat{g}(\boldsymbol{k})\hat{\psi}^*_{s,\theta}(\boldsymbol{k})\} \tag{3}$$

where is the complex wavelet coefficient, s is the width or dilation responsible for the resolution of the wavelet, θ is the rotation parameter, k is the 2D wave number, $\boldsymbol{F}^{-1}$ is the inverse 2D Fourier transform, $\hat{g}(\boldsymbol{k})$ is the 2D Fourier transform of the signal $g(x)$, $\hat{\psi}^*_{s,\theta}(\boldsymbol{k})$ is the complex conjugate of $\hat{\psi}_{s,\theta}(\boldsymbol{k})$, where

$$\hat{\psi}_{s,\theta}(\boldsymbol{k}) = s\hat{\psi}(s\Omega^{-1}(\theta)\boldsymbol{k}) \tag{4}$$

is the 2D Fourier transform of the 'daughter' wavelets which are obtained by dilating, translating and rotating the mother wavelet. $\Omega(\theta)$ is the rotation matrix. Superposition of Morlet wavelets is performed to produce isotropic and complex wavelet coefficients. The admittance is obtained by taking the ratio of cross spectra of gravity and topography to power spectra of gravity:

$$Z(s, x) = \frac{\langle \tilde{g}_{sx\theta}\tilde{h}^*_{sx\theta}\rangle_\theta}{\langle \tilde{g}_{sx\theta}\tilde{g}^*_{sx\theta}\rangle_\theta} \tag{5}$$

where $\tilde{g}_{sx\theta}$ and $\tilde{h}_{sx\theta}$ are the complex wavelet coefficients of Bouguer anomaly and topography/bathymetry respectively.

The advantage of fan wavelet method over other spectral methods in isostatic calculations lies in the fact that the CWT provides local as well as global spectra unlike the FT which yields only global spectra. Although the windowed Fourier transforms (e.g. multitaper method) provides spatial variations, the fan wavelet is still better since it employs an optimal sized window for each scale (Kirby and Swain, 2004).

4 Spatial T_e analysis and results

Seven windows (W1, W2, W3, W4, W5, N1 and N2) of size 990 × 990 km^2 are used to compute the effective elastic thickness (T_e) of the Indonesian subduction zone. The spatial resolution of the T_e output is 0.1° which reveals the regional spatial variations. Figure 2 (W1) represents the Andaman–Northern Sumatra subduction zone. Predominantly high range of T_e (40 65 km) is observed over the fore-arc segment, which is the epicenter location of a number of historic and neotectonic earthquakes include the events of 1914 (M7.2), 1941 (M7.7), 1955 (M7.2), 2004 (7.2), 2005 (7.3), 2009 (7.6) and others. A small portion of fore-arc through which the Sumatra Fault is running, is exhibiting a reduction of lithospheric strength ($T_e < 40$ km). A high range of T_e can also be observed in the subducting plate in the close proximity to the trench axis, through which northernmost segment of NER is running.

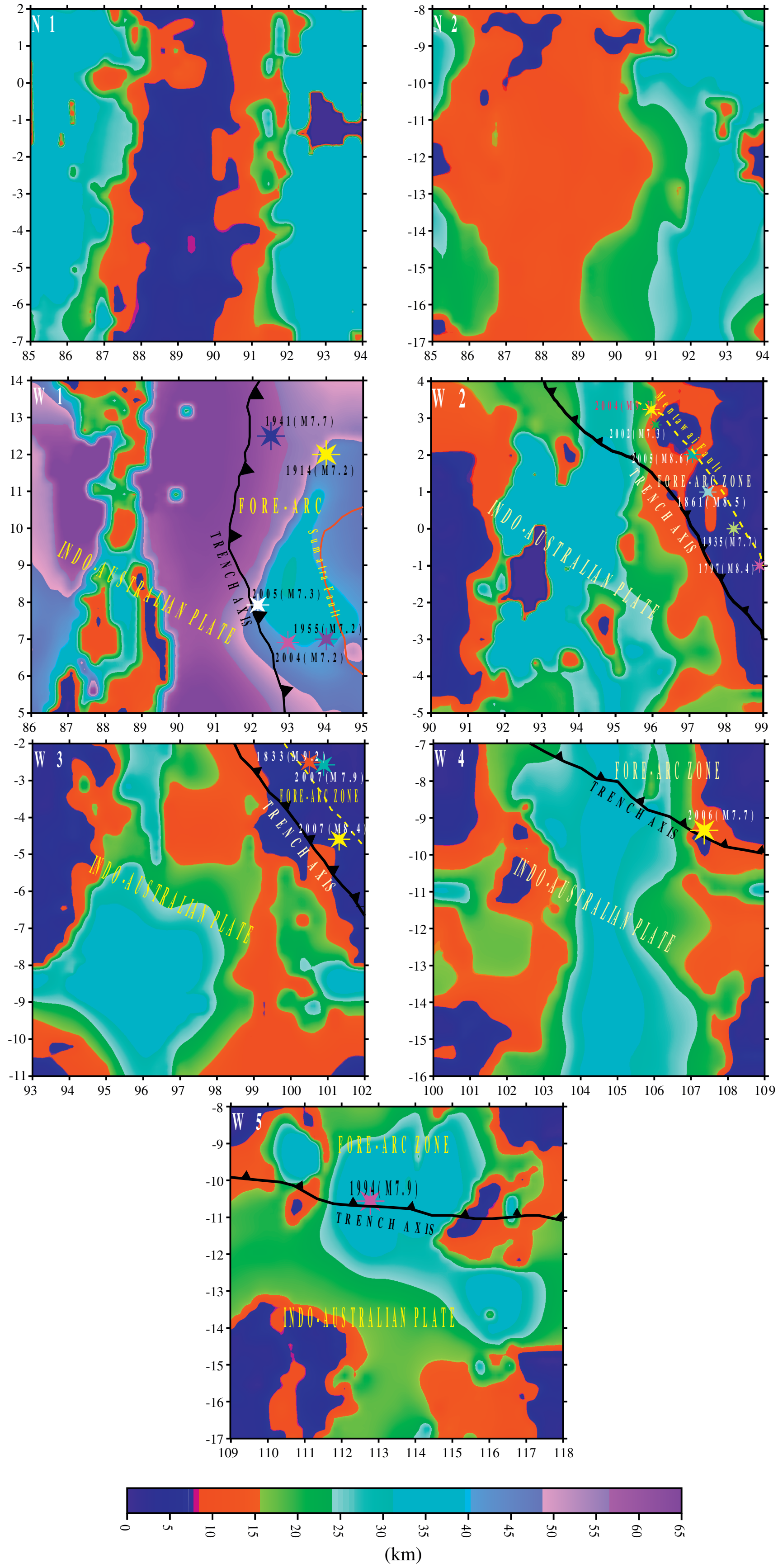

Figure 2. Estimated effective elastic thickness (T_e) maps for the corresponding Windows (W1, W2, W3, W4, W5, N1 and N2) showed in figure 1. Each T_e window is marked by the epicenter locations (stars) of major earthquake events ($M > 7$) in that region.

Figure 2 (W2) includes part of northern and southern Sumatra subduction zone. Isostatic response analysis over the fore-arc segment reveals an anomalously Low Fore-arc T_e (LFT_e) range (0–20 km) which coincides with the epicenter locations of 2004 (M 9.3), 2002 (M7.3), 2005 (M8.6), 1861 (M8.5), 1935 (M7.7), and 1797 (M8.4) major earthquake events. Mentawai strike-slip fault runs across the LFT$_e$ zone, appears to align with all of these earthquakes showed in W2. Southern Sumatra subduction zone, W3 (figure 2) captures a significant wide LFT$_e$ patch (T$_e$ < 20 km), again aligned with the historic and neotectonic megathrust events (Konca, 2007; Grevemeyer and Tiwari, 2006) (1833, M9.2; and the events happened in 2007: M8.4 and M7.9) occurred adjacently on both sides of the Mentawai fault, is the characteristic feature of southern Sumatra fore-arc.

Comparatively high range of T$_e$ (20–40 km) is captured in the W4 (figure 2), encompiring the Java fore-arc region. A neotectonic major earthquake of 2006 (M7.7) has occurred in the low T$_e$ zone so far in this region. Figure 2 (W5), which is the continuation of Java subduction zone shows a comparatively high range of T$_e$ (20–40 km) throughout the fore-arc zone. One major earthquake event of 1994 (M7.9) occurred in this high T$_e$ fore-arc zone. The prominent T$_e$ low over the oceanic plate can be observed over the intermittently scattered bathymetric highs.

Over the subducting Indo–Australian plate the T$_e$ found to be varies predominantly on the ridge segments (The NER and the Investigator ridge). The T$_e$ estimates over the southern segments of the NER included in figure 2 (N1 and N2) are exhibiting a low T$_e$ range (∼0–15 km). Whereas the prolongation of the Northern segment of NER lying in the close proximity to the trench axis exhibits high T$_e$ range (40–65 km). The Investigator Ridge segment which lies near to the trench axis on the subducting oceanic plate (figure 2 W3) is also exhibits a low T$_e$ (<15 km).

5 Discussions

The error in T$_e$ estimation (figure 3) $\delta Z(\boldsymbol{k})$ is found to be varying from 0–4 km for all the windows, which indicates qualitatively the admittance estimate is robust. In the current study using the fan wavelet technique the error in estimating T$_e$ has been performed by considering the reciprocal wavenumber weighting between the observed and predicted admittance. The errors obtained by this technique are proportional to the equivalent Fourier wavenumber. Contrary to other error estimation methods, this method down-weight the noisy admittance estimates occurring at high wavenumber thereby producing smoother T$_e$ results.

The estimated T$_e$ values over Andaman–Sumatra and Java subduction zones in the seven windows (figure 2) indeed demonstrates the tectonic regime of both the subducting and overriding plates near to the trench axis. T$_e$ observations in the Andaman-Northern Sumatra region (Figure 2 W1) shows a high T$_e$ range(40–65 km) which is consistent with the idea of Singh *et al.*, (2005) that WAF forms a lithospheric boundary with different friction coefficients promoting discontinuity in coupling or locking strength between subducting Indian plate and Burma plate. They deduced this locking depth as 30-40 km near the WAF. The NER segment adjacent to the Andaman trench exhibits high T$_e$ range similar to that observed in the fore-arc, which is the indicative of complexities in subduction within the region. We interpret that the northern part of the NER adjacent to the Andman trench has been already participated in the subduction process and because of the stacked crustal loads it has been locked at the interface between the subducting and overriding crusts. The subduction in the Andaman trajectory is therefore very sluggish or temporarily on hold, and thus large magnitude earthquakes are less frequent in this region. The rate of subduction in Andaman region (14 mm/yr) (Lay *et al.*, 2005) is comparatively very less to that in Sumatra (52–60 mm/yr) and in Java (80 mm/yr) (Lasitha *et al.*, 2006), justifies our findings. This locked subduction geometry might have resulted in the high strength estimates in the Andaman subduction zone.

The T$_e$ estimates of the southern parts of the NER (figure 2 N1 & N2) lying far away from the trench axis, exhibits a low T$_e$ (∼0–15 km). This is indicating that the subduction complexities have not affected in the segments south of the equator, and thus the obtained low T$_e$ estimates can be attributed to the geodynamic evaluation of the NER like the hotspot origin and the subsequent isostatic compensation of the plume load.

A bimodal T$_e$ distribution, obvious from the fore-arc segment of Sumatra (0–20 km) and Java (20–40 km) will be the most diagnostic observations from the T$_e$ windows (W2 to W5). Shallow focus earthquakes (∼30 km) are mostly observed in Sumatra–Java fore-arcs (Grevemeyer & Tiwari, 2006; Konca *et al.*, 2007). Grevemeyer & Tiwari (2006) demonstrated evidence that magnitude of the shallow earthquake is regulated by the coupling at the interface between subducting and overriding plates. They proposed that a serpentinized mantle wedge would limit the width of the coupling zone of Java only to 30–40 km and that of Sumatra to less than 120 km. Our bimodal T$_e$ variation of 0–20 km in Sumatra and 20–40 km in Java substantiate these findings. We infer that LFT$_e$ patches are associated with large magnitude seismicity and are the zones of high strain accumulation, resulting from a deficit in slip rate along the crustal interface from the actual rate plate convergence. Chlieh *et al.*(2008) used geodetic and paleogeodetic measurements of interseismic strain and imaged heterogenous pattern of coupling in Sumatra region. These patch works of high strain accumulation (Konca *et al.*, 2008; Chlieh *et al.*, 2008) conforms well to the LFT$_e$ patches that estimated from isostatic response analysis. Song & Simons (2003) predicted that shear stress is higher where a negative TPGA is observed and lower where a positive TPGA is observed. Hyndman & Peacock (2003) demonstrated that up-dip limit is associated with a change of frictional properties in the thrust occurring at temperature of 100–150°C. Bostock *et al.*(2002) explain the role of water trapped in the crust and mantle and formation of serpentinization. The models of Grevemeyer & Tiwari (2006) shows that serpentine rheology in subduction zones have a strong influence on the mechanical coupling between

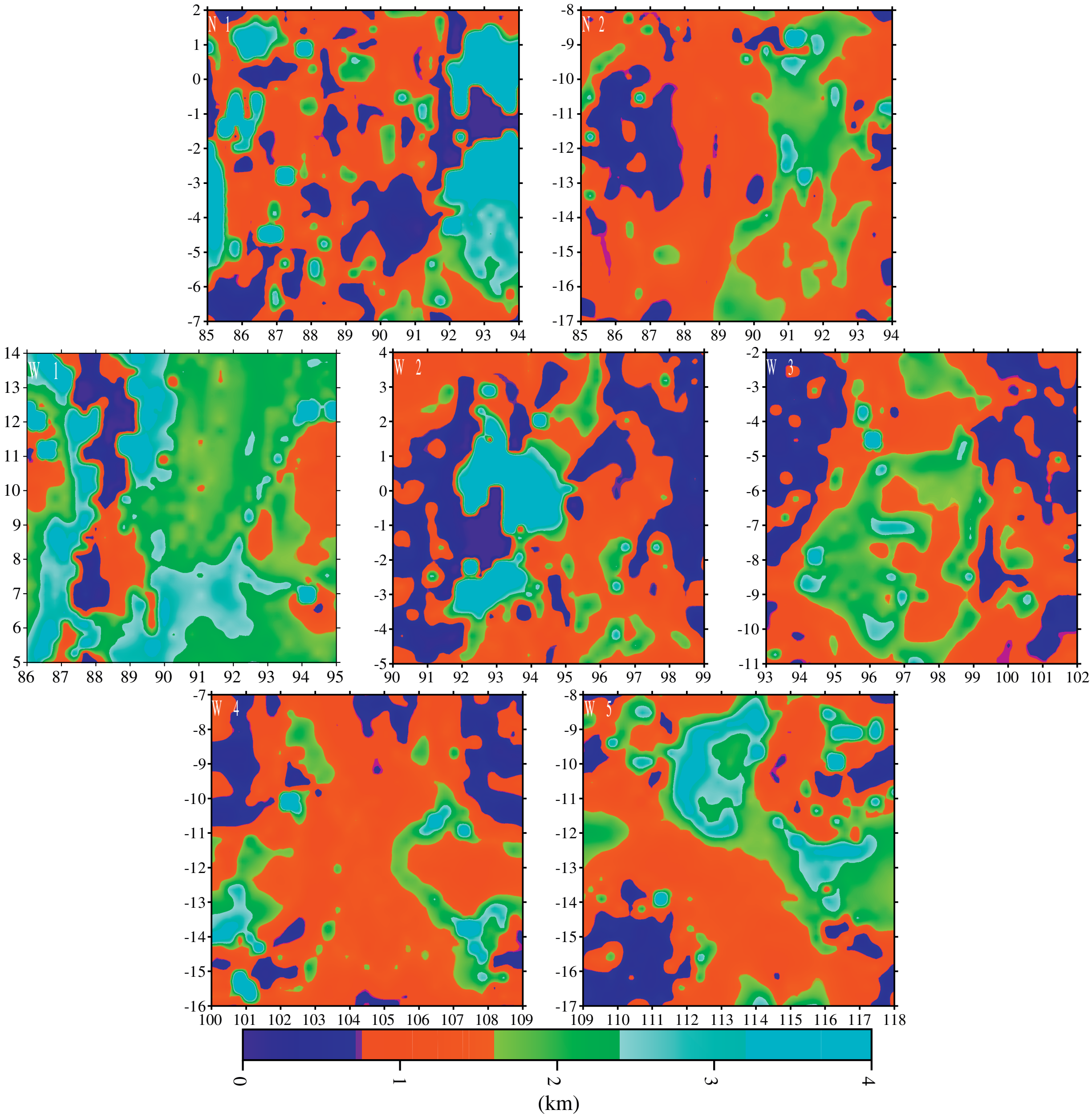

Figure 3. Error on T_e estimation corresponding to the windows (W1, W2, W3, W4, W5, N1 and N2).

slab and mantle wedge. Seno (2005) proposed that hydration of fore-arc mantle wedge occurs through the hydro-fracturing of subducted crust and inferred that stress state of the wedge would determine the extent of serpentinization of the fore-arc mantle wedge.

Our observation of most of the earthquakes aligned along the Mentawai fracture zone within the LFT_e patch suggests an upward migration of expelled aqous fluids from the down-thrusting crust through this fractured conduit instead of forming serpentinization at the down-dip region. This will result in a wide interseismic coupling due to the increasing friction at the interface between the subducting and overriding crustal segments and is assumed to be the possible reason for the strength reduction and the occurrence of shallow-high magnitude seismicity in the Sumatra fore-arc (figure 4a). We now propose a narrow-weak interseismic coupling for Java leads to its comparatively high strength and less seismicity of the fore-arc zone. The normal subduction of an old-cold lithosphere (138 Myr) (Grevemeyer & Tiwari, 2006) at a convergence rate of 80 mm/yr (Lasitha *et al.*, 2006) may promote a decoupling at the interface. Since Java fore-arc is devoid of active fractures of regional extent (Newcomb & McCann, 1987), it prevents the migration of water from the interface. Thus, the water released from the subducting crust can percolate into the fore-arc mantle peridotite to form hydrous minerals like serpentine and help for a slippage, thus leading to an earthquake of small magnitude; rather than a large strain accumulation at the interface (figure 4b).

6 Conclusions

A summary of our results of flexural analysis applied to the Sumatra–Java subduction zone shows that:

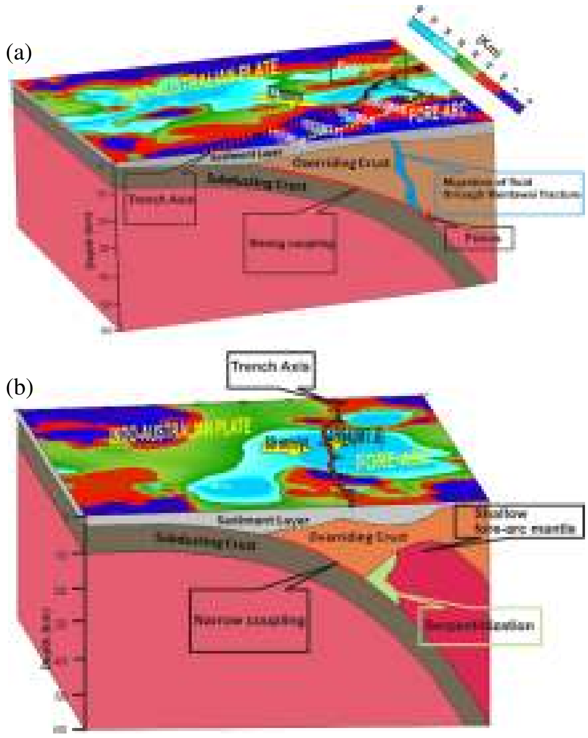

Figure 4. 3-D cartoons for Sumatra–Java subduction zones, demonstrating T_e variation along with the subduction geometry and earthquake mechanism (after Grevemeyer and Tiwari, 2006). (a) T_e surface is exhibiting an oblique convergence of the Indo-Australian oceanic plate at a rate of 52 mm/yr along the Sumatra trench and the LFT_e patch (T_e < 20 km). The representation of a strong coupling zone at the interface between the subducting and overriding crustal segments beneath the LFT_e patch is revealing the tectonic correlation between the interseismic coupling and the fore-arc T_e variation. The trace of the Mentawai fracture at depth is symbolized by a fractured conduit which is the way of fluid migration from the down-dip region. The earthquake focus is shown at the down-dip, where the subducting crust meets the fore-arc mantle, demonstrating the mechanism of earthquake events plotted at the T_e surface. (b) The T_e surface representing the Java subduction zone exhibits a normal subduction of the Indo–Australian plate. The spatial T_e high at the fore-arc region is explained by means of a shallow fore-arc mantle model (Grevemeyer and Tiwari, 2006) and a narrow coupling zone at the interface. Absence of deep lying fractured conduits and hence, the existence of serpentinization at the down-dip explains the comparatively less seismic behavior of the Java zone.

1. The high mechanical strength estimates and less occurrence of great magnitude earthquakes in the Andman subduction zone can be attributed to the locked subduction geometry resulted by the partial subduction of the stacked NER load.

2. Over the Sumatra fore-arc segment, T_e map obtained shows an anomalously Low Fore-arc T_e (LFT_e) range (0–20 km) over the Sumatra fore-arc (figure 2 W2 and W3) coinciding with the epicenter locations of previous major earthquakes: 2004 (M 9.3), 2002 (M7.3), 2005 (M8.6), 1861 (M8.5), 1935 (M7.7), 1797 (M8.4), 1833 (M9.2), 2007 (M8.4 and M7.9) and others. This is suggestive of a very weak lithosphere exhibiting crustal thickening due to diffused deformation (figure 5) at all crustal levels and thus can promote fracturing and upward migration of fluids.

3. Over the Java for-arc segment, a high range of T_e (20–40 km) is obtained as shown in W4 and W5 (figure 2). This is in stark contrast with Sumatra suggestive of a strong lithosphere and shallow fore-arc mantle.

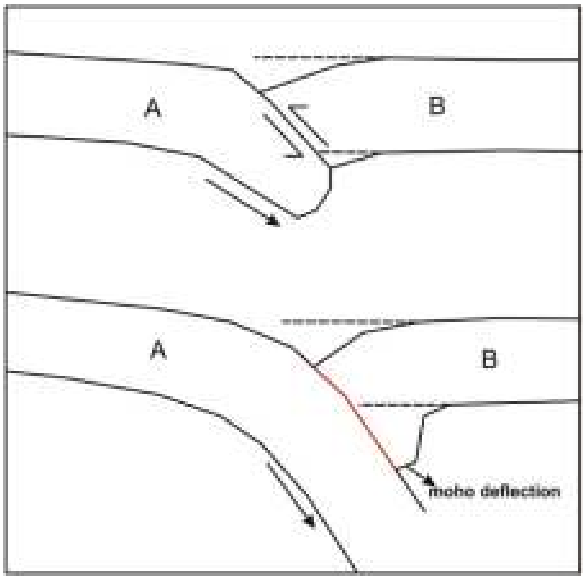

Figure 5. Cartoon demonstrates fore-arc crustal deformation mechanism (a) Couple force is induced at the interface between the under-thrusting (A) and overriding (B) crusts and the bending and stretching of the overriding plate begins. (b) After the deformation by stretching of the overriding crust, the Moho boundary shifts into a deeper position resulting in a wide interface (red line) and subsequent crustal thickening.

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Numerical simulation experiments of the devastating Orissa super cyclone 1999

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ABSTRACT

An accurate and well-in-advance forecast of track and intensity of the TCs is essential for disaster management purpose. In the present study numerical experiments are conducted to simulate the track and intensity of the Orissa super cyclone (1999) using Mesoscale Model MM5 with three domains configuration (45-15-5 km resolution). Experiments are conducted with variation in the cumulus parameterization schemes namely Grell (Gr), Betts-Miller (BM) and updated Kain-Fritsch (KF2). The forecast tracks indicate strong influence of cumulus parameterization schemes (CPS) on the large scale steering flow. KF2 and Gr could simulate the track in the north-west direction which is close to the observed track estimated by India Meteorological Department (IMD). The CPS BM and Gr underestimated the intensity. The CPS of KF2 could simulate the maximum intensity, rate of intensification comparable to the observation also it could simulate the dynamic and thermodynamic structure of the mature cyclone. The results suggest that it may be possible to predict track, intensity and inner-core structures of devastating tropical cyclones with the help of high grid resolution and realistic model physics configuration

1 Introduction

Tropical cyclones variously defined as hurricanes, typhoons, and cyclones regularly impact human populations and periodically produce devastating weather-related natural disasters. The destructive forces of cyclonic winds, inundating rains, and storm surge are frequently accompanied by floods, tornadoes, and landslides. The Super Cyclone of October 1999 in the Bay of Bengal (Orissa Super Cyclone hereafter OSC-99) was one of the severest of the century to landfall over east coast of India and was the most intense TC in the history of Orissa State. Orissa Super Cyclone was the case of rapid intensified cyclone. After genesis in the Andaman sea it tracked northwestward across the Bay of Bengal and intensified as a super cyclonic Storm. The intensification was at a greater than climatological rate. It made landfall at about 35nm south-southeast of Cuttack and 30 nm southeast of Bhubaneswar, India. Associated maximum surface wind was 140 knots (72 ms^{-1}) as estimated by India Meteorological Department (IMD 2000) and lowest Central Sea Level Pressure (CSLP) was 912 hPa. As per the information received through the media, 10,000 people lost their lives due to this super cyclone. Wind speed of 250 kmph lashed most parts of the Orissa coast and tidal waves of height 12–14 meters inundated low-lying areas along the Orissa coast. Prediction of track and intensity of such a devastating cyclones well-in-advance is necessary for disaster management purpose. Numerical models based on well defined dynamical and physical processes provide toll for predicting such weather phenomena.

2 Description of numerical experiments conducted

The Penn State/NCAR Fifth Generation of Mesoscale Model (MM5 version 3.7) is used to carry out the sensitivity experiments for this study. The MM5 is a non-hydrostatic model with a terrain following sigma vertical coordinate system. Detailed description of MM5 is

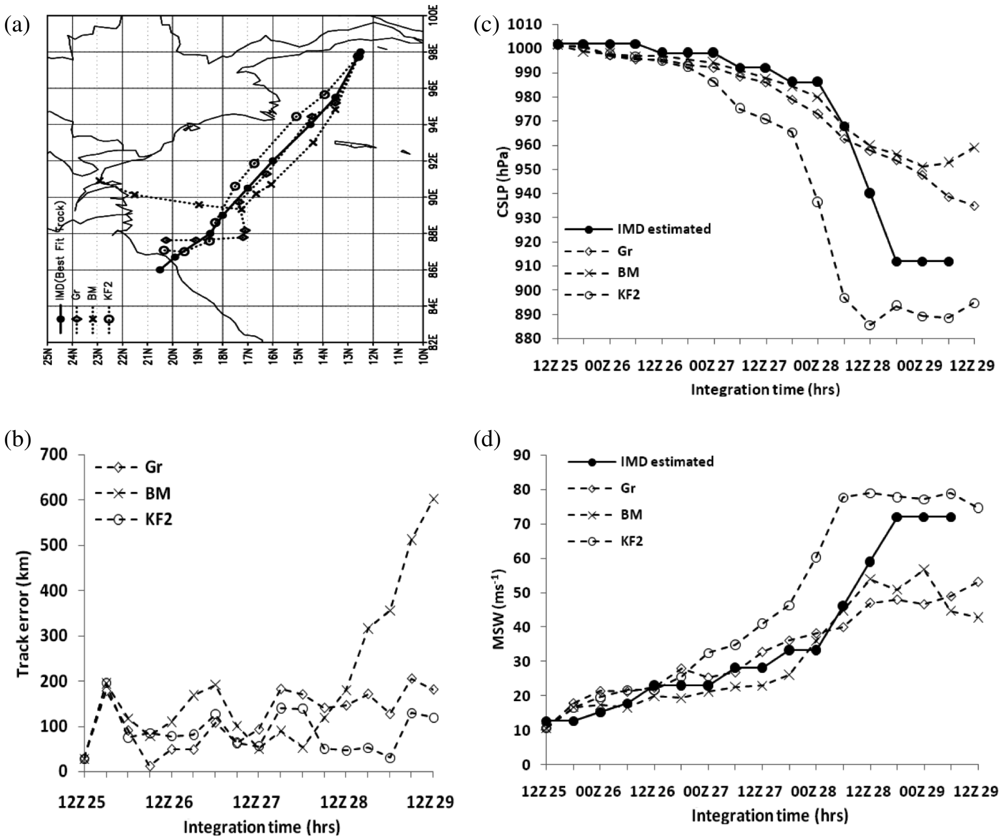

Figure 1. Model simulated tracks (a) and time series plots of track error in km (b), Central Sea Level Pressure (CSLP) in hPa (c) and Maximum Wind Speed (MSW) in ms^{-1} (d) at the lowest model level for the experiments of sensitivity to different CPS along with IMD data.

given by Grell *et al.*(1994). The sensitivity experiments with different convective parameterization schemes (CPS) include Grell (Grell 1993), Betts-Miller (Betts and Miller 1986) and updated Kain–Fritsch (KF2, Kain 2004) in combination with Eta Mellor-Yamada (MY, Mellor and Yamada 1982) scheme for Planetary Boundary Layer Parameterization and Mixed Phase (MP, Reisner *et al.*1998) scheme for cloud microphysics parameterization. Three interactive nested domains at the resolution of 45 km (domain D1-110 × 110 grid points), 15 km (domain D2-154 × 154 grid points) and 5 km (domain D3-226 × 202) are used. All model domains have 23 vertical unequal (sigma) levels with higher resolution in the planetary boundary layer. The initial and boundary conditions for the model domains are obtained from ECMWF 40 year's reanalysis data (ERA-40) data set. The time varying lateral boundary conditions are obtained at every 12 h interval during the entire simulation period i.e., from 1200 UTC October 25, 1999 to 1200 UTC October 29, 1999). The model is integrated in a two-way interactive fashion. During first 24 hours only outermost domain (D1) is active. Domain D2 is activated at 12:26-10-1999 and D3 is activated at 12:27-10-1999.

3 Results and discussion

The performance of the model is evaluated towards prediction of track and intensity of the storm. The errors in track prediction are presented in terms of vector displacement errors compared to the observed track of the storm as reported by India Meteorological Department (IMD report 2000). The intensity of the storm is examined in terms of Central Sea Level Pressure (CSLP) and Maximum Wind Speed (MWS) at the surface.

3.1 Sensitivity to CPS

The plots of track, track error and intensity variation with time for sensitivity to CPS are shown in Figure 1(a–d). As per IMD observations after initial formation in the Andaman Sea the system moved straight in north-west direction. All three CPS gives track in north-west direction close to the observed track upto 72 hrs of integration, after which the difference in the track forecast between the CPSs is significant. Specifically the track with BM and Gr is in northward direction after 72 hrs whereas KF2 storm moves in northwest direction up to 90th hr of integration then it turns to the north. Overall the track with KF2 is close to the observation with minimum track error and BM gives maximum track error among all CPS studied here. Figure 1(c–d) compares simulated and observed (IMD estimated) time variation of Central Sea Level Pressure (hPa) and Maximum Wind Speed (ms^{-1}) during 1200 UTC 25 October - 1200 UTC 29 October 1999. All the experiments start from the same initial conditions and initial storm intensity matches well with the observed intensity. Intensity variation is less sensitive for all three schemes and is comparable with the IMD estimated intensity upto 30th hour of integration. Then onwards KF2 overestimates the intensity. The intensity variation is same for Gr and BM

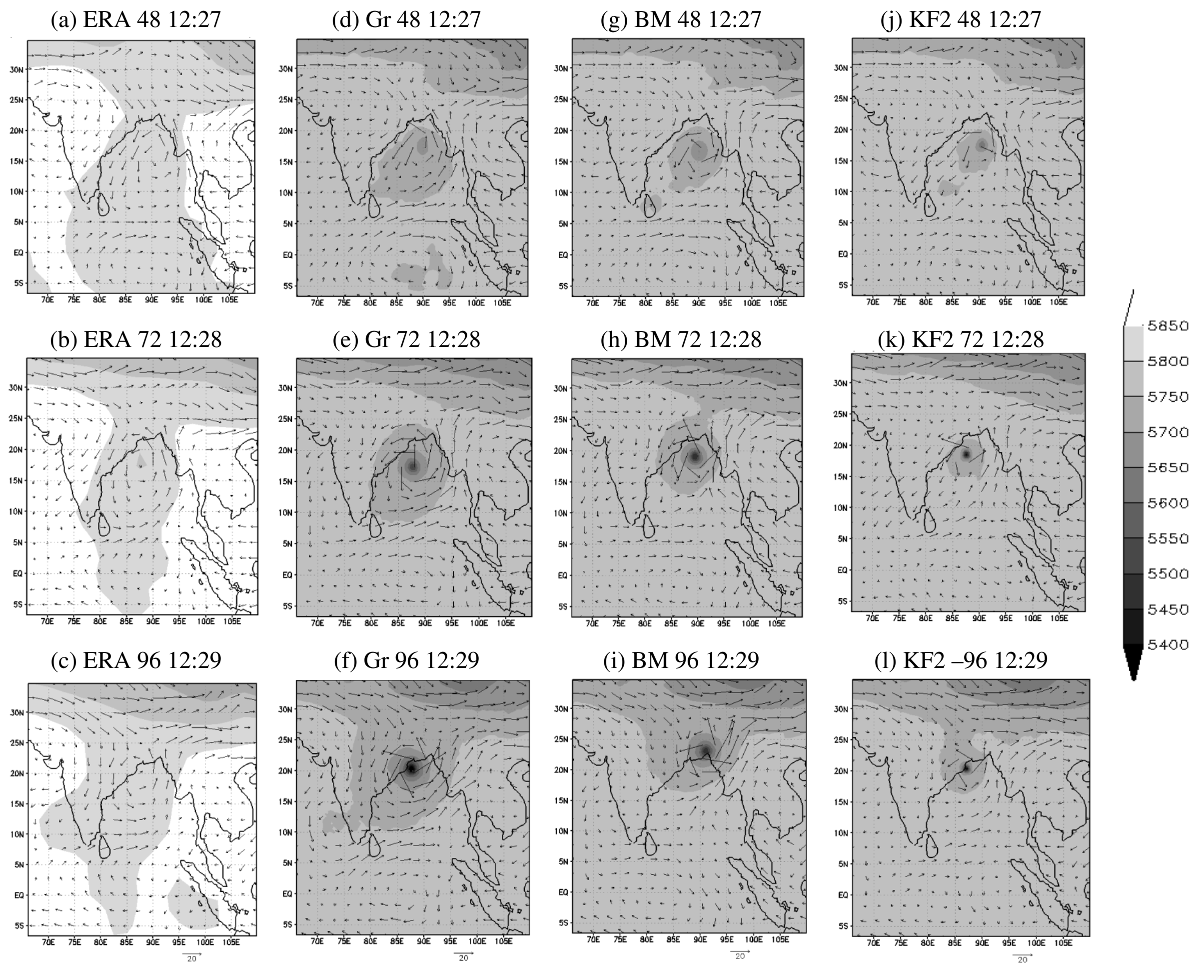

Figure 2. Geopotential height in meters (shaded) and wind direction (vectors) at 500 hPa for ERA-40 data (a-c), Gr (d-f), BM (g-i) and KF2 (j-l) experiments in the outermost mesh (45 km) at 48 (12:27-10-1999), 72 (12:28-10-1999) and 96 (12:29-10-1999) forecast hours.

which is comparable to the IMD estimated values upto 66 hrs of integration. Then onwards both the schemes underestimate the intensity. The minimum CSLP are 935 hPa (on 12:29-10-1999), 951 hPa (on 00:29-10-1999) and 886 hPa (on 12:29-10-1999) with Gr, BM and KF2 respectively. Only KF2 could simulate the super cyclone (MWS > 62 ms^{-1}) and the fast intensification at the rate of 4.4 hPa hr^{-1} comparable to the IMD estimated rate of 4.1 hPa hr^{-1} though the intensification phase is 6 hrs prior to the observations. After reaching the maximum intensity similar to the observed storm the storm with KF2 maintained the almost constant intensity till the land fall.

These results clearly demonstrated the profound sensitivity of cyclone's track and intensity forecast to the variations in cumulus parameterization schemes. To discuss some of the possible causes for these results, Figure 2(a–l) represent 500 hPa geopotential height in meters (shaded) and wind direction (vectors) for ERA-40 data (a-c), Gr (d-f), BM (g-i) and KF2 (j-l) each at 48, 72 and 96 hrs of integration. There were two anticyclones over land, which tend to oppose the cyclone's northwestern motion and the cyclone was likely to move towards West Bengal. But the system intensified into a super cyclonic storm and dominated over the anticyclone present over land and continued to move in the northwestward direction.

The intensity of the BM storm is week so the anticyclone over the land dominated to oppose the northwestward track and the cyclone travelled towards North. Among the three CPS schemes only KF2 could simulate the intense cyclone and thus could simulate the northwestward track.

Weak vertical wind shear of the horizontal wind is one of the factors supporting the intensification. Figure 3 shows the time series of the wind shear with three CPS. The plot shows the wind shear values averaged

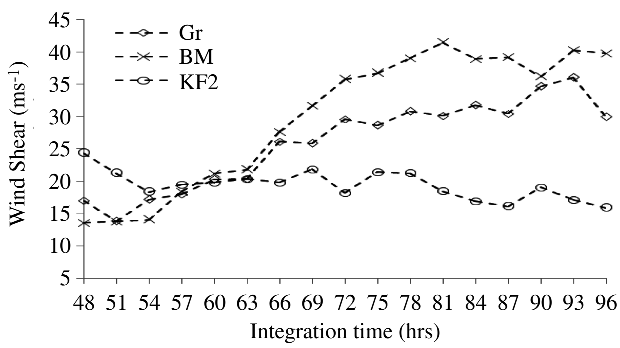

Figure 3. Time series of wind shear (m/s) averaged over an area of 20 x 20 around the storm centre.

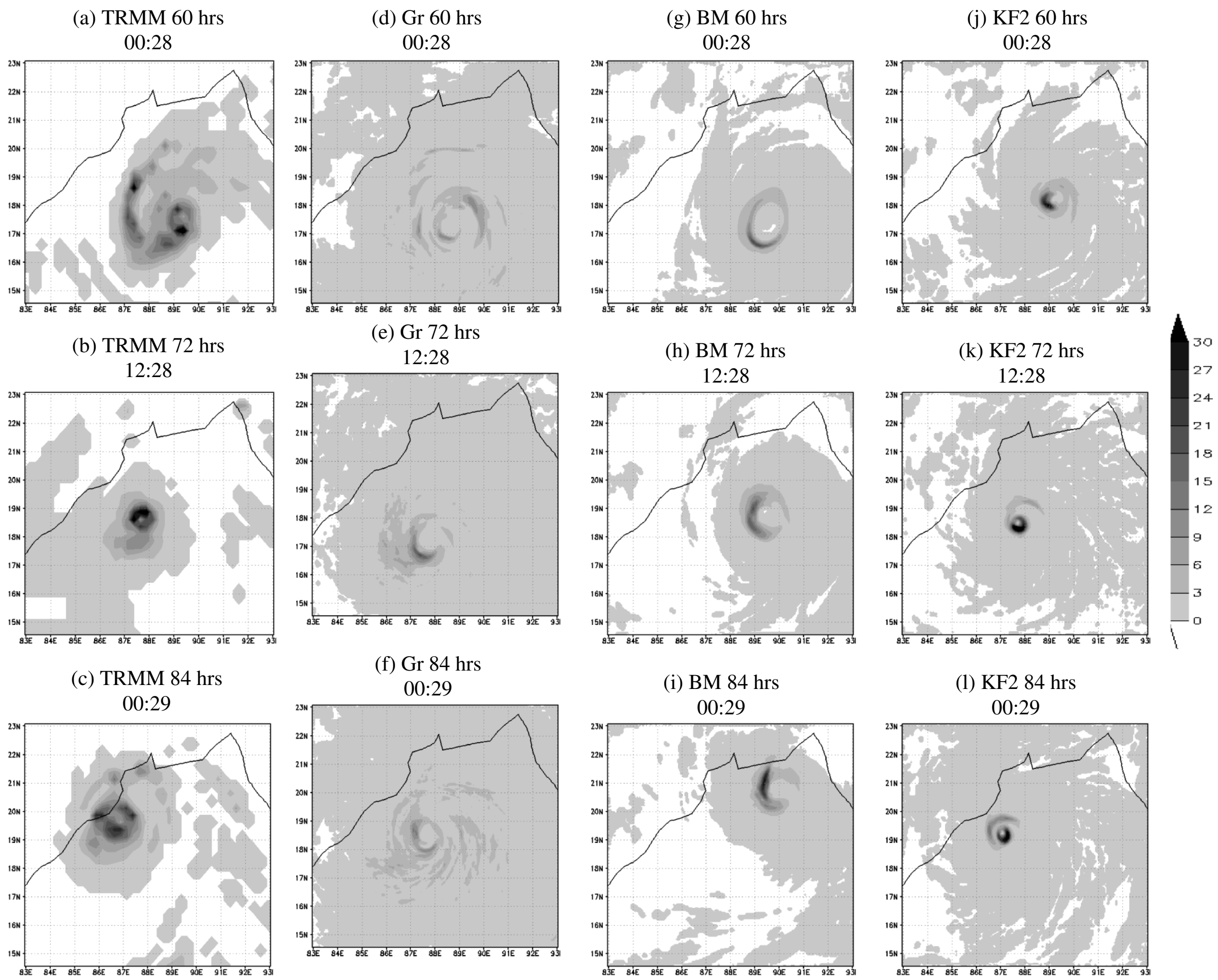

Figure 4. Model simulated rain per 3 hrs for three CPS during rapid intensification stage (60-84 hrs) of the observed storm along with that obtained from the TRMM for comparison.

over an area of $2^0 \times 2^0$ around the storm centre. The wind shear is increasing for Gr and BM after 63 hrs of integration which is slightly decreasing for KF2. During rapid intensification phase of the KF2 storm, the shear is almost constant. Throughout the integration the wind shear is minimum for KF2 and maximum for BM which is giving the strongest and weakest storm respectively.

Figure 4(a–i) displays the rain accumulated in 3 hrs for each of the experiments during rapid intensification stage (60–86 hrs) of the observed storm along with that obtained from the TRMM satellite data for comparison. The rain rate is comparatively less for Gr simulated storm hence the week storm. For BM simulated storm the rain rate is more after 84 hrs when the storm started intensifying. The KF2 storm which has simulated the rapid intensification phase has also simulated the maximum rain in the core. This large amount of precipitation releases significant amount of latent heat and this provides a positive feedback to the eyewall buoyancy and reducing pressure thus facilitates inflow and intensification of the storm.

To verify the system scale features the simulated radar reflectivity is shown in Figure 5. The development of organized spiral cloud bands with an echo free eye in its central core is well simulated with KF2. It is clear that during the fast intensification stage the eyewall continues to contract, the symmetric reflectivities increases, and the storm intensifies rapidly. Kalsi and Srivastava (2006) reported the similar changes in the eye size and the radius of maximum reflectivity. They observed the lowest radius of maximum reflectivity was 8 km at 02:29-10-1999. The radar reflectivity indicates the precipitation field and rainfall rate. In the case of KF2 the simulated radar reflectivity is more that 60 dBZ in the eyewall.

3.2 Vertical structure of the simulated cyclone

The inner-core structure of TC plays a very significant role in modulating it's intensify (Liu *et al.*1999). The OSC-1999 was a case of explosive deepening. Therefore it is desirable to examine vertical structures of the cyclone simulated with each cumulus parameterization schemes in terms of kinematics and thermodynamical parameters. The zonal cross section (across the latitude passing through the storm centre) of tangential wind speed (ms^{-1}), vertical velocity (ms^{-1}), temperature deviation (K) and relative humidity (%) are displayed in Figures 6(a–d) respectively at the mature stage of the cyclone (00:29-10-1999).

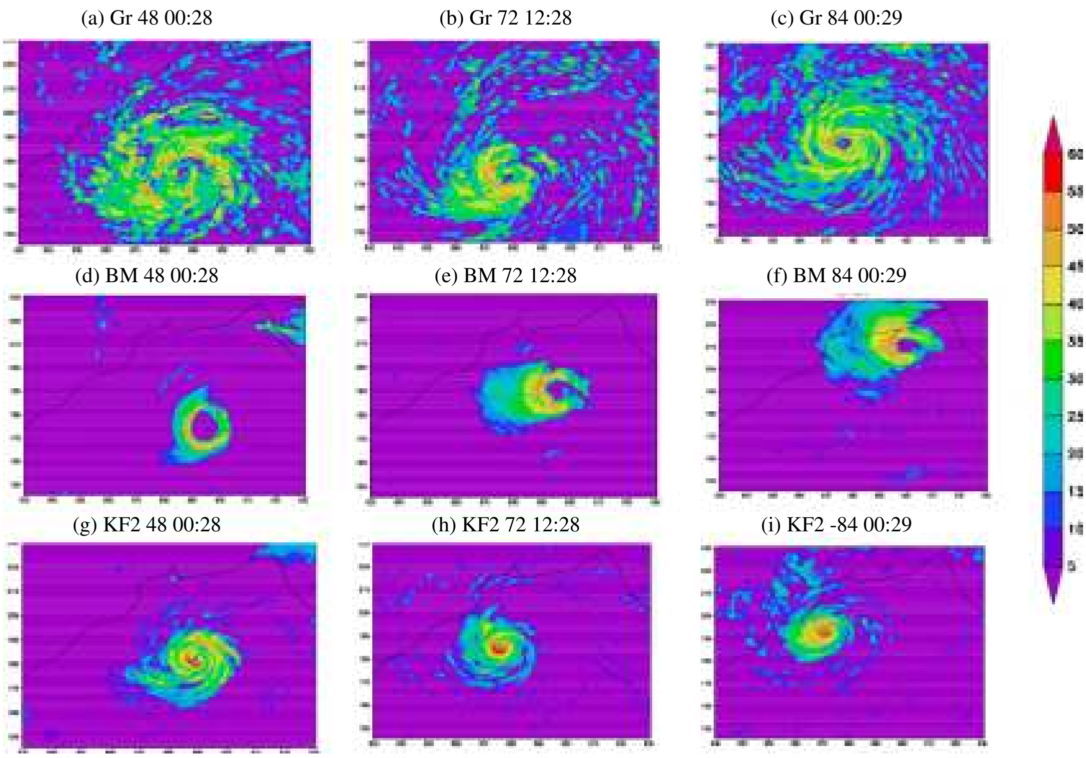

Figure 5. Model simulated Radar Reflectivity (dBZ) for three CPS during rapid intensification stage (60–84 hrs).

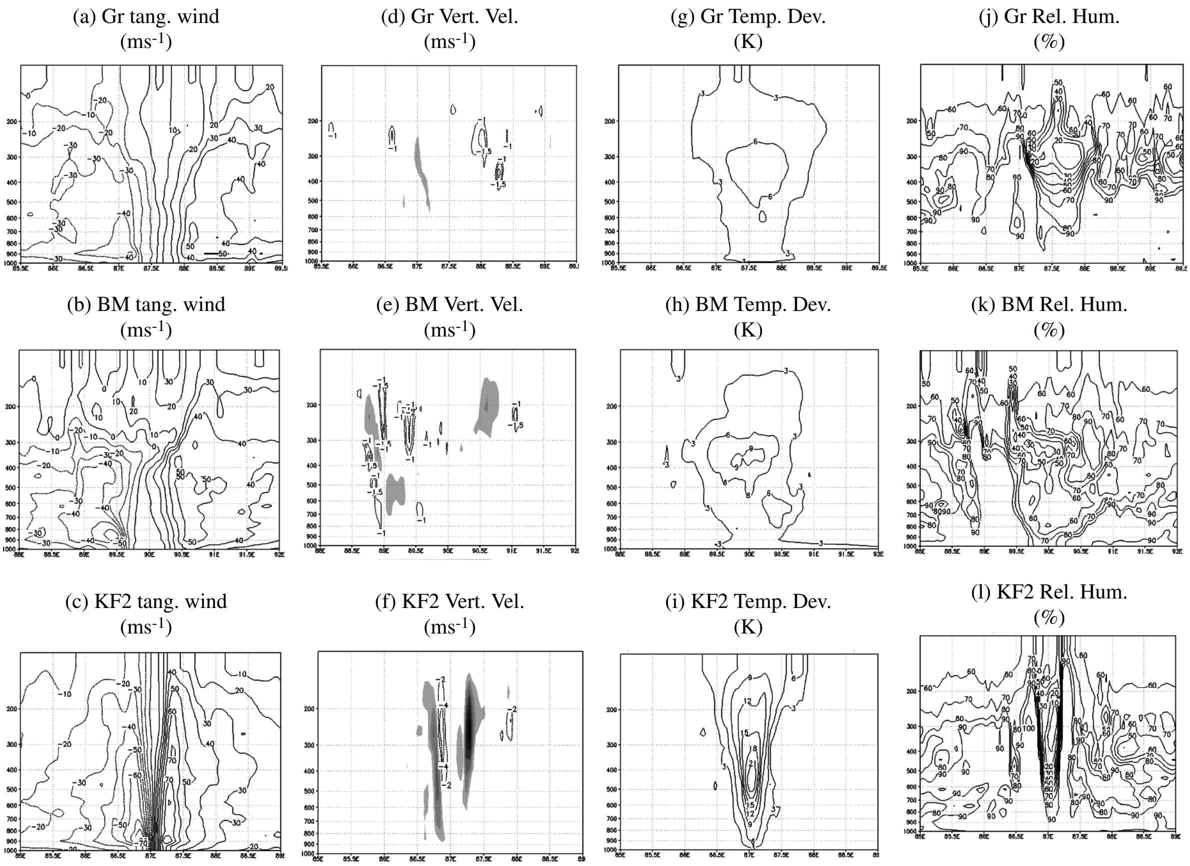

Figure 6. The east-west cross section at 00:29-10-1999 of simulated (a-c) tangential wind (ms^{-1}), (d-f) vertical velocity (ms^{-1}), (g-i) temperature deviation (°C), (j-l) relative humidity (%), The horizontal axis denotes longitude and vertical axis denotes pressure levels (1000 hPa to 100 hPa).

The most striking feature of tropical cyclone structure is the intense tangential wind which is shown in Figure 5(a–c). Only KF2 shows the formation of eyewall structure. There is existence of the Radius of Maximum

Wind (RMW) throughout the troposphere in the eyewall with isotachs tilting outward with height. The wind maxima (>70 ms^{-1}) are roughly at 900 hPa, its magnitude decreases sharply outwards. This typical eyewall structure is absent in the Gr and BM storms. Maximum tangential wind speed is 50 ms^{-1} for Gr and BM where as it increases from 50 to 80 ms^{-1} during the fast intensification phase of the KF2 storm.

Another important kinematic structure of the mature cyclone is its vertical velocity (w) which is shown in Figure 6b. The updrafts are shaded and downdrafts are shown with dotted contours. Updrafts with a narrow width on both the sides of eye and subsidence between the updrafts are very well simulated in the KF2 storm particularly at 84 hrs when storm reached its maximum intensity. Updrafts in the eyewall are sloping outward with height and maximum value of the updraft is about 12 ms^{-1}. Maximum downdraft occurs in a narrow zone close to the inner edge of the slopping eyewall. The maximum value of downdraft is about 6 ms^{-1}. These features are not seen for Gr and BM simulated storms. The maximum values of updraft and downdraft are 6 ms^{-1} and 1.5 ms^{-1} respectively for Gr and 4 ms^{-1} and 2 ms^{-1} respectively for BM.

To gain insight into the generation of the extremely low pressure at the centre, Figure 6c presents a vertical cross section of temperature deviation during the fast intensification stage. A marked warm core structure from the surface to the 100 hPa is evident in the eye for all three CPS but warming is maximum for KF2 (21 K), whereas the maximum temperature deviation is of 6 K for Gr and of 9 K for BM. The level of the maximum temperature departure from the surrounding is between 500–300 for Gr, 400-300 for Gr and 400–500 hPa for KF2 at the mature stage.

Relative humidity has a substantial impact on the distribution of precipitation and convection in tropical cyclones. These in turn influence tropical cyclone structure and intensity change. The relative humidity field for KF2 shows a moist region associated with the eyewall and outflow jet and a dry zone related to the eye. Dry air close to the center can contribute to cold downdrafts and weakening of storms, while large lower-tropospheric relative humidity has been correlated with the potential for rapid deepening by Kaplan and DeMaria (2003).

4 Conclusion

Numerical experiments are conducted using MM5 to simulate the track and intensity of Orissa Super Cyclone. Three cumulus parameterization schemes namely Gr, BM and KF2 are considered here to study its impact. It is noted that the track and intensity both are sensitive to CPS. Only KF2 could simulate the track, intensity, rapid intensification and inner core structure of the OSC-99. As verified with the best analysis and the satellite data, the model captures exceptionally well the evolution and inner core structures of the storm in particular the explosive deepening rate (between 0000 UTC and 1800 UTC of 28 October) of the Orissa Super Cyclone 1999 i.e. 4.4 hPa hr^{-1} comparable to the IMD estimated rate of 4.1 hPa hr^{-1}. The simulated minimum surface pressure of 886 hPa and the strong surface wind of 79 ms^{-1} are comparable with India Meteorological Department (IMD) reported values of 912 hPa and 72 ms^{-1} respectively. It is clearly seen that the MM5 model is capable to simulated kinematic and thermodynamic structures in the core region at the mature stage which are found to be comparable with such intense cyclone cases in other regions as reported in the theoretical and observational studies.

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Numerical simulation of severe cyclonic storm LAILA (2010): Sensitivity to initial condition & cumulus parameterization scheme

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ABSTRACT

The cumulus processes play an important role in predicting the track, intensity and inner core structure of the tropical cyclones. Its adequate representation becomes one of the most challenging tasks in mesoscale numerical simulation and prediction. The present study explores the sensitivity of initial condition and cumulus processes on the numerical simulation of severe cyclone LAILA (maximum surface wind of 55kt and lowest central pressure of 986 hPa as per IMD observation) during pre-monsoon season (May 2010) over Bay of Bengal. Mesoscale Model WRF with two 'two-way' interactive nested domains at resolutions of 60 km, 20 km is used. Total 8 experiments are conducted using KF, BMJ, GD and new Grell as cumulus schemes and 00UTC of 16th May (observed state- no disturbance) & 00UTC of 17th May (observed state-low pressure area) as two different initial conditions provided by GFS data of $1^0 \times 1^0$ degree resolution. The results show that BMJ scheme produces relatively better track than other schemes. Simulated results are improved when the initial conditions are supplied prior to formation of low.

1 Introduction

Tropical cyclones that form over the Bay of Bengal during pre and post monsoon seasons cause considerable damage and destruction to lives and property over the east coast of India & Bangladesh. The destruction is due to strong gale winds, torrential rain and associated tidal wave. Timely and reasonably accurate prediction of the tracks and intensities of such cyclones can minimize the loss of human lives and damage to properties. Though the general behavior of the movement of the tropical cyclones is well known, it is desirable to have as much as accurate prediction as possible of the landfall for effective implementation of the disaster mitigation. The numerical models based on fundamental dynamics and well-defined physical processes provide a useful tool for understanding and predicting TC. For accurate forecast of TCs, it is essential that numerical models must incorporate realistic representation of important physical and dynamical processes as they play principal role in determining its genesis, intensification and movement (Anthes 1982, Ross & Kurihara 1995). Pattnayak S. & Mohanty (2008) did a comparative study on the performance of MM5 and WRF models in the simulation of Tropical cyclone over Indian sea. For the three cases of very severe cyclonic storms (Mala, Gonu, Sidr), no. of meteorological fields viz. Central pressure, wind and precipitation have been varified against observations. They concluded that WRF model has better performance in respect of track and intensity prediction than MM5 model. Bhaskar Rao et.al 2006, 2007, Srinivas et.al 2007 examined the role of the parameterization of convection, planetary boundary layer (PBL) and explicit moisture processes on track & intensity of tropical cyclone using MM5. The result shows that convective processes control the movement of the model storm while PBL processes plays crucial role in determining the intensity of cyclone. Deshpande M *et al.*(2010) discussed the impact of different physical parameterization schemes on numerical simulation of super cyclone Gonu using MM5 model. They found that model forecast track as well as intensity is more sensitive to cumulus schemes than PBL and explicit moisture schemes. This strongly indicates that the choice of appropriate cumulus parameterization scheme in the model will minimize the errors in track forecast. As like in the short range weather prediction, numerical prediction of tropical cyclones is dependent on the accuracy of the initial conditions provided for the model integration. Therefore in present study, the effect of cumulus parameterization and the effect of initial condition on forecasting track & intensity of tropical cyclone are investigated.

2 Case description

A case of pre-monsoon, Bay of Bengal cyclone named 'LAILA' during May 2010 is selected for the study. According to India Meteorological Department (IMD) a low pressure area is formed over southeast Bay of Bengal in the evening of 16^{th} May 2010. This low pressure area is rapidly concentrated into Depression & further intensified into deep depression and lay centered at 1730hrs IST of 17^{th} May over southeast Bay of Bengal, about 850kms east southeast of Chennai. It moved westwards & intensified into Cyclonic storm (Laila) at 0530 hrs IST of 18^{th} May 2010 near lat 11.5^0N & lon.86.5^0E. Continuing its movement in the northwest direction cyclonic storm Laila is further intensified into Severe Cyclonic Storm at 1130 hrs IST of 19^{th} May 2010 & lay centered within a half a degree of lat 13.5^0E & lon. 81.5^0N. Severe Cyclone Laila is further moved in west northwest direction and crossed the Andhra Pradesh coast near Bapatla between 1630 & 1730hrs IST of 20^{th} May 2010. After landfall it is immediately weakened into Cyclonic storm & lay centered at 1730 hrs IST of 20^{th} May very close to Bapatla. It remained stationary for sometime and further weakened into Deep depression & lay centered at 0830 IST of 21^{st} May over north coastal Andhra Pradesh about 50 km north of Machilipatnam. It is weakened into well marked low pressure area on 1730 IST of 21^{st} May 2010.Severe cyclonic storm Laila recorded a minimum central pressure of 986hPa and a maximum wind speed of 55kt.

3 Model description

Numerical experiments in this study are performed using the WRF (Weather Research and Forecasting) model (version 3.1.1). The WRF employs a fully-compressible and non-hydrostatic equation set in a terrain following vertical coordinate, which is based on the dry hydrostatic mass in the column but is otherwise like a standard sigma coordinate. The finite difference equations include a high-order advection with the 3^{rd} order Runge-Kutta time scheme, and a time-splitting technique for sound waves that are treated explicitly in the vertical on shorter sub-time steps. Mass and other scalar fields are numerically conserved in this finite difference equation system.

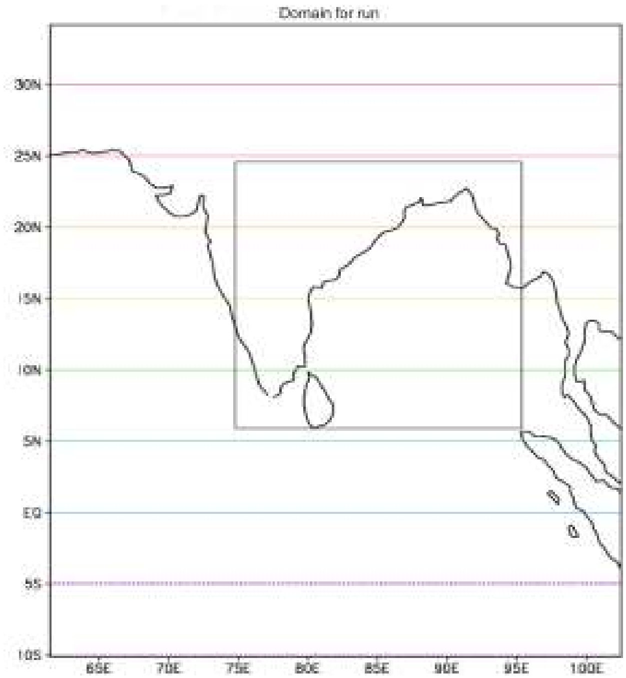

Figure 1. Domain of integration for all experiment.

Two nested domains, daughter domain with 20km horizontal resolution lying completely inside the parent domain of 60km resolution are selected. For physical processes, the WSM6 explicit microphysics scheme and the YSU PBL scheme are employed. Four CPSs i.e. KF, BMJ, GD and new Grell are employed for the sensitivity experiments. The model is initialized with two different initial conditions Expt. 1) from 00UTC 16^{th} May (observed state- no disturbance) and Expt. 2) from 00UTC of 17^{th} May 2010 (observed state- low pressure area).

4 Data and methodology

Initial conditions for the two model domain have been interpolated from GFS data available at $1^0 \times 1^0$ resolutions corresponding to 0000UTC of 16^{th} May 2010. The model topography for the 60 and 30 km domain regions are obtained from the USGS topography data at 10'and 2' resolutions. The time varying lateral boundary conditions are derived at every 12 hr interval during the period 00UTC of 16^{th} May to 00UTC of 22^{nd} May. The intensity and the position of Laila cyclone are taken from RSMC report provided by IMD.

5 Results

Figure 1 shows the domain of integration for all sensitivity experiments. Figures 2a & 2b compare the best observed track by IMD with the simulated tracks for two initial conditions (Expt. 1 & Expt. 2). In fact, GD & new Grell scheme is not able to simulate the cyclonic circulation in both the cases, however slight circulation is

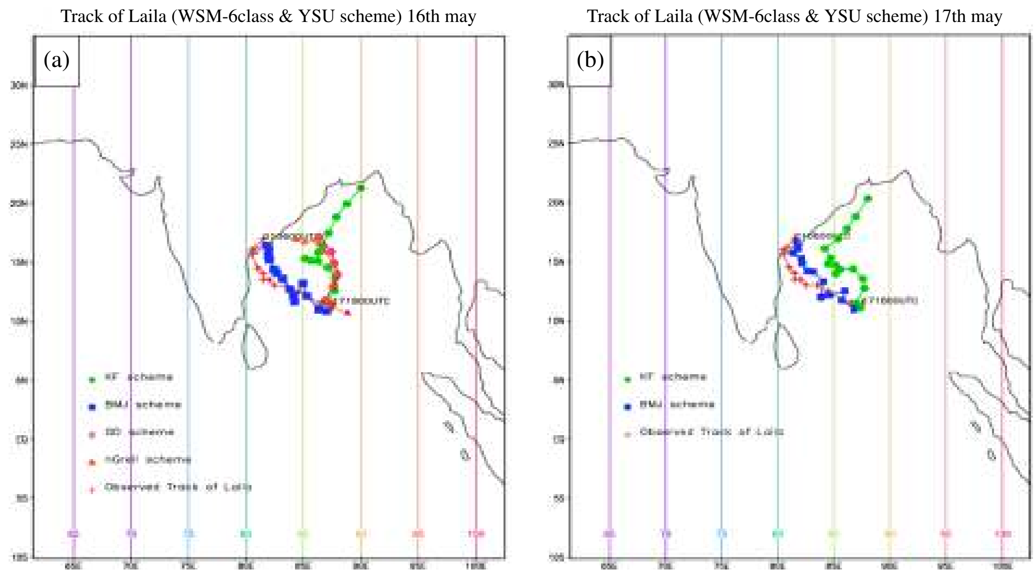

Figure 2. Observed and simulated track of cyclone Laila (a) initial condition-16th May, (b) initial condition- 17th May 2010.

Table 1. Summary of numerical experiments.

Model	**WRF 3.1.1**
Horizontal resolution & Time step	Two nested domain 60 km, 20 km with 270sec, 90 sec
Numerical integration period	5 days each (results examined at 6 hr interval)
Initial conditions	1. 00UTC of 16th May 2. 00UTC of 17th May 2010
Cumulus scheme	1. Kain Fritsch 2. Betts-Miller-Janjic 3. Grell-Devenyi 4. New Grell
Microphysics scheme	WSM6 class
PBL scheme	YSU
Radiation	SW – Dudhia LW -RRTM
Four cumulus schemes and two initial conditions give total eight experiments.	

noticed only for the case of 16th may as initial condition. Therefore track of GD and new Grell scheme are not shown in Figure 2b. The track forecast errors are shown in Figure 3a & 3b for KF & BMJ cases. In both the cases of initial condition, BMJ scheme is found to be closer to the observations. KF scheme shows northeastward movement of cyclone, so the track forecast error is also found to be increased due to larger deviation from the observations. In general track forecast error lies in the range of 50–300 km throughout the integration period. It is 185 km prior to landfall when the integration is started prior to LoPar and it is 225 km when the integration started on 17th may. In terms of intensity of cyclone, the minimum central pressures and maximum surface winds are compared and shown in Figures 4 & 5. In general both the cumulus parameterization schemes i.e. BMJ & KF overestimate the intensity of cyclone as compared with the observed one. However, the results of KF scheme are not discussed as the cyclone track produced by KF is far away than BMJ scheme. In the first experiment with BMJ scheme, initially minimum central pressure and maximum surface winds are underestimated and thereafter from 18UTC of 19th May, they are overestimated with min. central pressure of 978 hPa and maximum surface wind of 42 ms^{-1}. In the second experiment also minimum central pressure and maximum surface winds are initially underestimated and then from 06UTC of 19th May, they are overestimated with min. central pressure of 970 hPa and 44 ms^{-1} as maximum surface wind. Thus overall results indicate that the intensity is overestimated in the second Expt. where the integration is started after formation of low. In the first Expt., landfall is at 21UTC of 20th May i.e. about 9 hrs late and in the second Expt. landfall is in between 00-03UTC of 21st May 2010 which is about 12–15 hrs late, as compared with the observations.

The vertical structure of the cyclone in both the Expts. is obtained 4–5 hrs prior to landfall i.e. 06UTC 20th May. By varying initial conditions, no significant change is noticed in the vertical structure of cyclone LAILA. Further, it is already noticed that the case of 16th may as initial condition gives less track error compared to the other case. Therefore the vertical structure for the first Expt. only is discussed here. The thermodynamic and dynamic structure of tropical cyclone is shown in

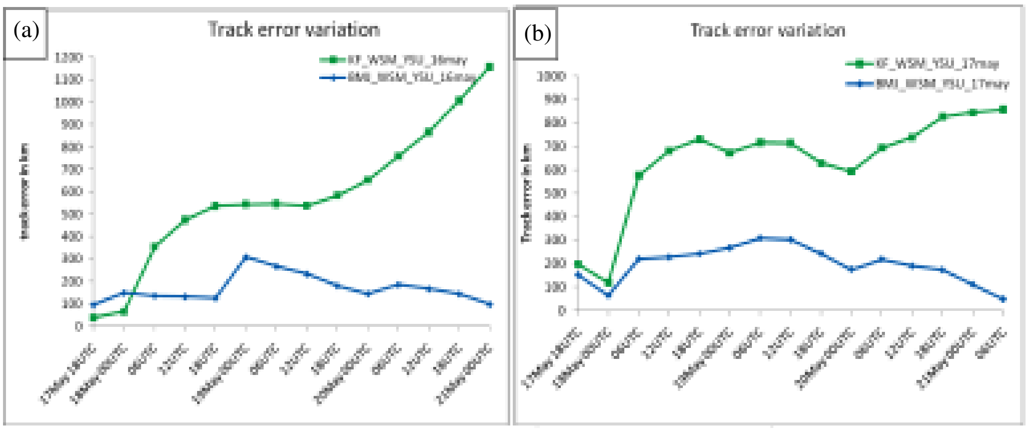

Figure 3. Variation of track forecast error for a) initial condition-16th May b) initial condition- 17th May 2010.

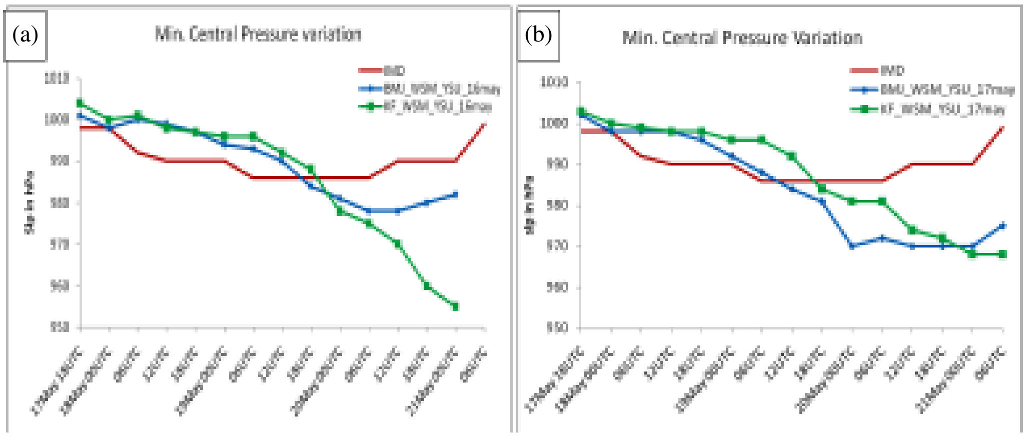

Figure 4. Variation of minimun central pressure for (a) initial condition-16th May, (b) initial condition-17th May 2010.

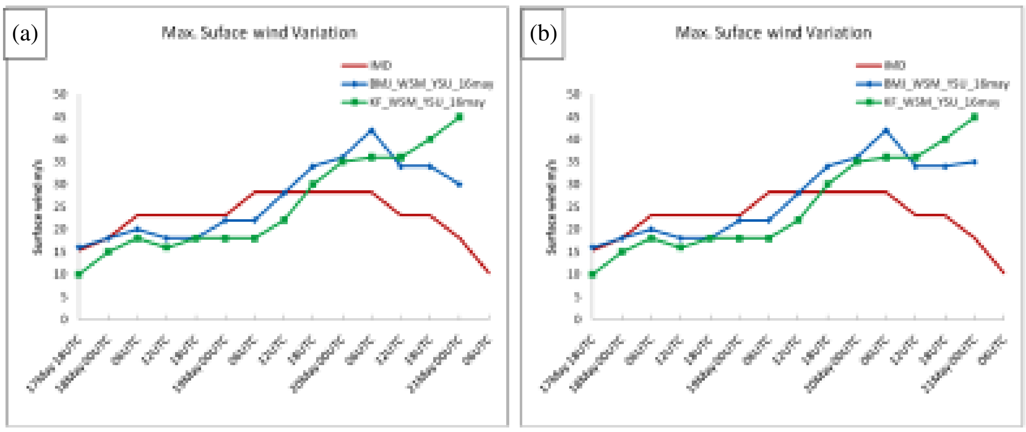

Figure 5. Variation of Maximum surface wind for (a) initial condition 16th May, (b) initial condition 17th May 2010.

Figures 6 & 7. The warm core structure with positive temperature anomaly of 5^{circ} C is clearly seen from Figures 6a & 6b. The eye is not much distinguished as LAILA is not the very severe or super cyclonic storm. The eye extent is limited upto 900hPa. The horizontal extent of warm core is found to be increasing with decreasing pressure.

Figure 7a & 7b shows vertical structure of vertical velocity and vorticity. The downdraft (negative vertical velocity) is clearly seen at the center of cyclone, though it is not extended upto the ground. This region of downward motion representing the sinking motion of air at the center of cyclone can be considered as an eye. Close to the sinking motion, the strong updraft (positive vertical velocity) upto 3.4 ms^{-1} is also seen which represents the eye wall of the cyclone. Cyclonic vorticity from the surface to 100 hPa near the centre of cyclone indicates the vertical extent of cyclone is from surface to tropopause. Magnitude of positive vorticity and upward motion are found to be consistent with each other. Strong cyclonic vorticity of about 18×10^{-4} is seen at around 950 hPa.

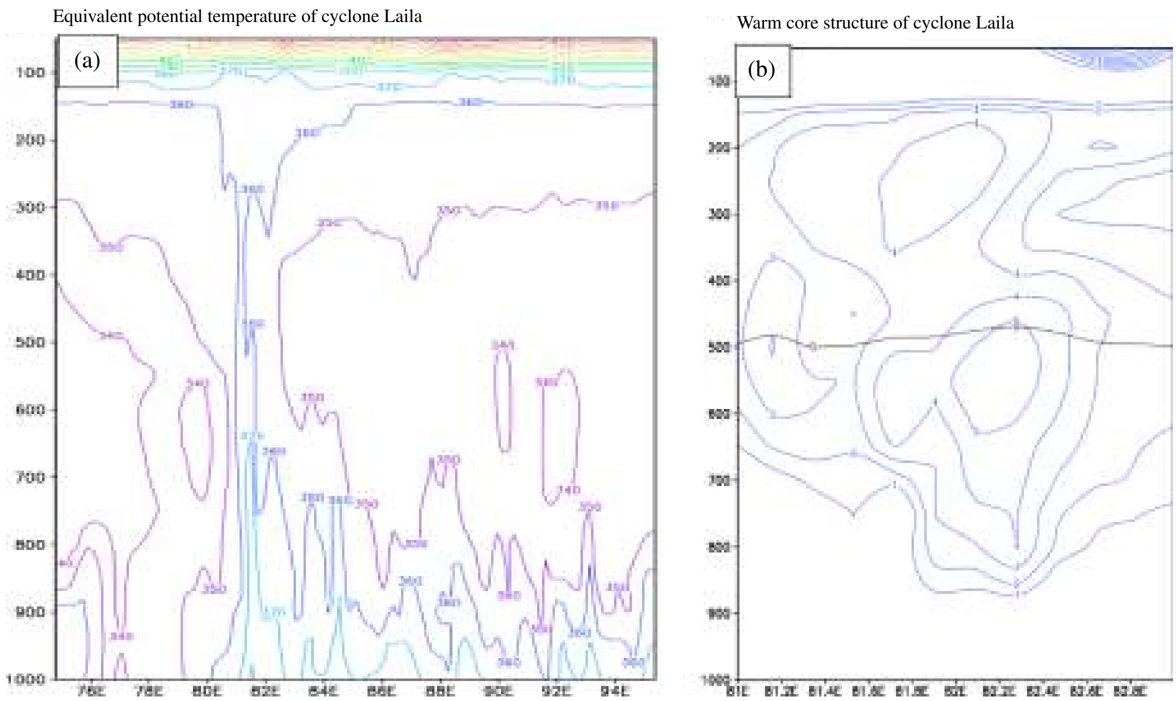

Figure 6. Vertical distribution of (a) equivalent potential temperature in K (b) temperature anomaly of cyclone Laila.

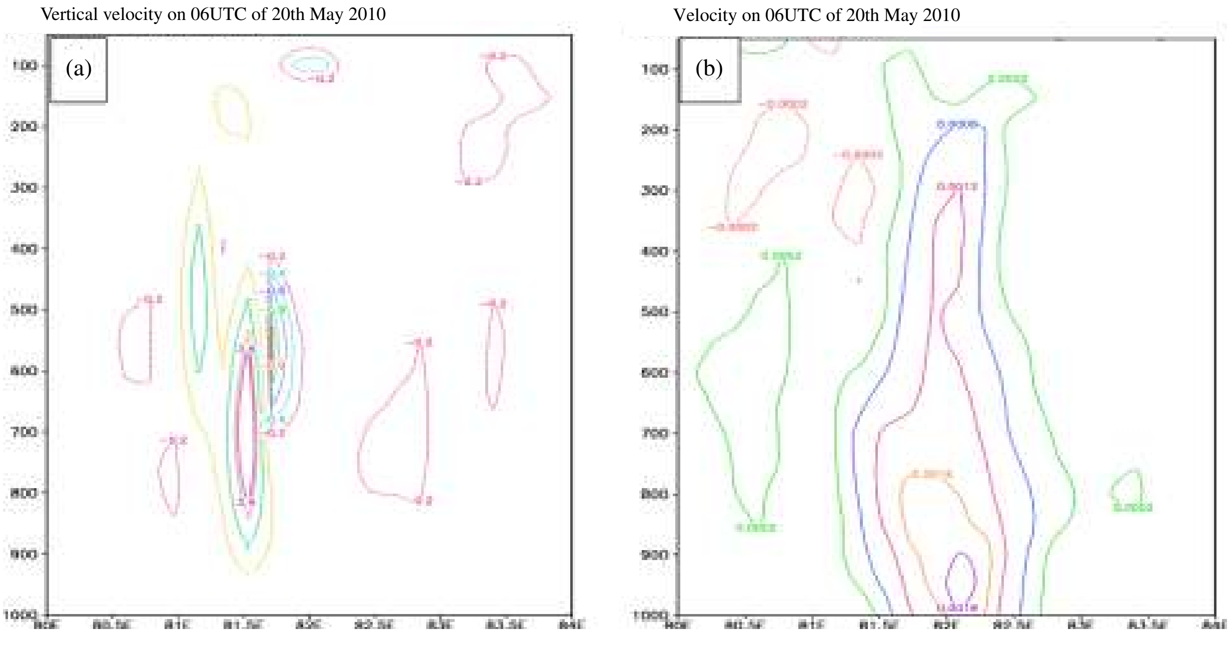

Figure 7. Vertical distribution of (a) Vertical velocity in ms^{-1} (b) Vorticity (s^{-1}) of cyclone Laila.

6 Conclusions

This paper presents the results obtained from a number of sensitivity experiments with Cumulus parameterization schemes and initial conditions towards the simulation of pre-monsoon Bay of Bengal cyclone. Some important inferences that can be drawn from these results are as follows:

Simulated surface track is found to be sensitive to cumulus parameterization as well as to the initial condition. When the initial condition is given prior to the formation of low, track error is found to be reduced. Simulated intensity is qualitatively found to be closer to the observation but it is overestimated prior to landfall. Thermodynamic and dynamic structure simulated by model indicates that cyclone has warm core structure with eye & eye wall and vertical extent of cyclone is upto 100 hPa. As results are improved when the initial condition prior to the formation of low is given, we can forecast the track as well as intensity in advance with reasonably good accuracy. Thus early warning of tropical cyclone can reduce the loss of lives and damage to property.

Acknowledgement

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A study on the human and psychosocial factors contributing to industrial accidents

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ABSTRACT

The human factor is very important for the achievement of the objectives of any organization without accidents. The human with his ability to feel, to think, to conceive and to plan is most valuable in the prevention of industrial accidents. The objective of this study is to know the causes of accidents due to human errors, and understand the importance of human behaviour, psychology and its role in preventing accidents.

1 Introduction

Human factors refer to environmental, organizational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety **(HSE, 1999)**.

This includes three interrelated aspects that must be considered: the job, the individual and the organization:

- **The job:** including areas such as the nature of the task, workload, the working environment, the design of displays and controls, and the role of procedures. Tasks should be designed in accordance with ergonomic principles to take account of both human limitations and strengths. This includes matching the job to the physical and the mental strengths and limitations of people. Mental aspects would include perceptual, attentional and decision making requirements.
- **The individual:** including his/her competence, skills, personality, attitude, and risk perception. Individual characteristics influence behaviour in complex ways. Some characteristics such as personality are fixed; others such as skills and attitudes may be changed or enhanced.
- **The organization:** including work patterns, the culture of the workplace, resources, communications, leadership and so on. Such factors are often overlooked during the design of jobs but have a significant influence on individual and group behaviour.

In other words, human factors are concerned with **what** people are being asked to do (the task and its characteristics), **who** is doing it (the individual and their competence) and **where** they are working (the organization and its attributes), all of which are influenced by the wider societal concern, both local and national. Human factors interventions will not be effective if they consider these aspects in isolation. The scope of what we mean by human factors includes organizational systems and is considerably broader than traditional views of human factors/ergonomics. Human factors can, and should, be included within a good safety management system and so can be examined in a similar way to any other risk control system.

2 Categorizing human failure

It is important to remember that human failures are not random; there are patterns to them. It is worth knowing about the different failure types because they have different causes and influencing factors and as a consequence the ways of preventing or reducing the failures are similarly different. There are three types of causes that may lead to major accidents:

- Unsafe action factors
- Psychosocial factors
- Personal factors

2.1 Unsafe action factors

Studies reveal that most of the unsafe actions of the employees are caused due to various factors. This can be given by

- **Errors (slips/lapses)** are "actions that were not as planned" (unintended actions). These can occur during a familiar task (e.g. omissions like forgetting to do something), which is particularly relevant to repair, maintenance, calibration or testing. These are unlikely to be eliminated by training and need to be designed out.
- **Mistakes** are also errors, but errors of judgment or decision-making ("intended actions are wrong") - where we do the wrong thing believing it to be right (e.g. failure to use personal protective equipments). These can appear in situations where behaviour is based on remembered rules or familiar procedures or unfamiliar situations where decisions are formed from first principles and lead to misdiagnoses or miscalculations. Training is the key to avoiding mistakes.
- **Intentional errors:**
  - **Violations** differ from the above in that they are intentional (but usually well-meaning) failures, such as taking a short-cut or non-compliance with procedures e.g. deliberate deviations from the rules or procedures. They are rarely willful (e.g. sabotage) and usually result from an intention to get the job done despite the consequences. Violations may be situational, routine, exceptional or malicious as outlined below.
  - **Routine violations:** a behaviour in opposition to a rule, procedure, or instruction that has become the normal way of behaving within the person's peer/work group.
  - **Exceptional violations:** these violations are rare and happen only in unusual and particular circumstances, often when something goes wrong in unpredicted circumstances e.g. during an emergency situation.
  - **Situational violations:** these violations occur as a result of factors dictated by the worker's immediate work space or environment (physical or organisational).
  - **Acts of sabotage:** these are self explanatory although the causes are complex - ranging from vandalism by a de-motivated employee to terrorism.

There are several ways to manage violations, including taking steps to increase their detection, ensuring that rules and procedures are relevant/practical and explaining the rationale behind certain rules. Involving the workforce in drawing up rules increases their acceptance. Getting to the root cause of any violation is the key to understanding and hence preventing the violation.

2.2 Psychosocial factors

Psychosocial risk factors are things that may affect workers' psychological response to their work and workplace conditions (including working relationships with supervisors and colleagues). Examples are:

- high workloads
- tight deadlines
- lack of control of the work and working methods
- home environment
- factory environment
- financial position
- addiction to intoxicating substances
- reckless attitude
- emotional instability
- dislike of superior

As well as leading to stress, which is a hazard in its own right, psychosocial risk factors can lead to musculoskeletal disorders. For example, there can be stress-related changes in the body (such as increased muscle tension) that can make people more susceptible to musculoskeletal problems; or individuals may change their behaviour, for example doing without rest breaks to try and cope with deadlines. So psychosocial factors need to be identified and controlled in order to have the greatest benefit. The best way to achieve this is by using an ergonomic approach, which looks at achieving the best "fit" between the work, the working environment and the needs and capabilities of the workers. Many jobs are not well designed and include some or all of the following undesirable features, which may lead to psychosocial risks:

- workers have little control over their work and work methods (including shift patterns);
- workers are unable to make full use of their skills;
- workers, as a rule, are not involved in making decisions that affect them;
- workers are expected to only carry out repetitive, monotonous tasks;
- work is machine or system paced (and may be monitored inappropriately);
- work demands are perceived as excessive;
- payment systems encourage working too quickly or without breaks;
- work systems limit opportunities for social interaction;
- high levels of effort are not balanced by sufficient reward (resources, remuneration, self-esteem, status).

2.3 Personal factors

The personal factors of the individuals are also needs to be identified and eliminated to prevent accidents. These factors disturb the mind of the employees and hence affecting their concentration on the job, reducing the interest to work, etc. Some of the personal factors can be given by

- age
- health condition
- day dreaming
- marital status
- physical problems (e.g. vision, fatigue, hearing, reaction time)

3 Control measures

Preventive measures must be considered and adopted as necessary for each of the above factors (unsafe action, psychosocial, and personal) through various control techniques and procedures. The unsafe action factors can be eliminated through the following methods.

- Proper selection of employees
- Education towards safety
- On job training
- Right placement
- Good supervision of workers
- Strict compliance to safe operating procedures
- Provision of safe working conditions
- Motivation

Whereas, the psychosocial and personal factors can be eradicated through

- Counseling
- Psychotherapies
- Yoga and Meditation

4 Discussion

There is more to managing human failure in complex systems than simply considering the actions of individuals. However, there is obvious merit in managing the performance of the personnel who play an important role in preventing and controlling major incidents, as long as the context in which this behaviour occurs is also considered. A detailed study on the human factors of the employees is essential in preventing the accidents and also to improve the morale and enthusiasm at work.

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Role of NGOs in disaster management

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ABSTRACT

Disaster Management plays a vital role in India's policy frame work. The poor and under privileged are worst affected due to calamities as well as Disasters. Disaster needs a special attention during pre-disasters besides relief and rehabilitation phases. It is matter of sorrow that every year in India about 125,000 persons die in road accidents and one third part of the nation's budget is being spent on accidents. In India, in every six minutes one person dies in Road accidents, over 17 million non-fatal injuries occur every year in work places which are serious enough to make people miss work and more than 45,000 workers suffer from fatal injuries on job every year. In Haryana & Punjab about 4,500 & 4,000 persons yearly respectively are dieing in road accidents. Perhaps such a large number of soldiers also never died in any war. There are many other NGOs working in the area of Disaster Management. International Committee of Red Cross and National Societies of Red Cross are playing vital role with dedicated filed operation and resource backup.

1 Introduction

1.1 Red cross

It provides its services in three phases Pre-Disaster, During Disaster and Post- Disaster. In the Pre-Disaster Phase, awareness and training programmes are most important to reduce the risk of disaster and to work for rehabilitation and recovery in Post-Disaster phase and also to reduce the mortality rate during disaster. Red Cross is doing humanitarian activities such as Voluntary Blood Donation Services, Old Age Homes, Drug De-addiction Centres, Working Women Hostels, establishment of First Aid posts & formation of Brigade Divisions in Schools and Colleges, provision of free medicines to Poor and Needy persons, promotion of Junior & Youth Red Cross activities in schools & colleges, Campaign against Female Foeticide, Red Cross & St. John Membership Campaign. School for Blinds is being run by the District Red Cross Branch, Hisar, and Services for the Mentally Challenged Children is being run by District Red Cross Branch, Rohtak.

1.2 The St. John ambulance

It is the Sister organization of Red Cross, which provides its services for the mitigation of disaster and play an important role all over the World. St. John Ambulance with its both wings "Association" and "Brigade" are a social humanitarian multi-racial voluntary organization, works in association with the Red Cross Society. In India St. John Ambulance Association was established in 1912 and St. John Brigade was established in 1928. It is also important to know that St. John Ambulance (India) through its State & District Branches is imparting First Aid training for the factory workers, Drivers, Police Personnel, Home Guards & Civil Defence Personnel, Students of Universities, Colleges & Schools as well as General Public. First Aid & Home nursing training is most important for all school going children, representatives of local government, Aanganwadi workers, and workers of NAREGA. The details of the trained First Aiders always remain with the respective State/District Braches of the St. John Ambulance as well as National Headquarters. In the State, 318 Brigade Divisions have been formed by the respective District St. John Centres. In its Administrative Structure, there is one Commissioner, One Deputy Commissioner, Four Assistant Commissioners and One Officer in each Division. Every year 80-100 Lay Lecturers' Training Course in First Aid & Home Nursing is being organized. After completing the success training, these Lecturers impart First Aid & Home Nursing training to the students of Schools & Colleges, Workers of Industries, Police Personnel, Home Guards Personnel, Drivers, Conductors, Professionals and common public to reduce the risk of disasters. At present 642 Lecturers are working in the State of Haryana.

2 Disaster phase

During Disaster so many persons die in absence of proper handling and timely help, which does not reach the affected/maimed persons. The services of the First Aiders can be utilized as they are the key persons to provide First Aid in a systematic way. They are trained to transport the casualties and can help the medical staff. National Disaster Management Authority, Govt. of India should take the services of First Aiders through St. John Ambulance (India). It is also a need of time that First Aid must be a compulsory subject in schools, colleges & other professional Institutions and Lecturers of First Aid should be appointed as Instructors through St. John Ambulance. During the Disaster phase, they can also provide leading role in technical support by motivating the public about safe construction, restore means of livelihood and can assist Government in monitoring Disaster Management Programmes. The First Aiders can also motivate the Local Resident Welfare Associations, Local Bodies, Panchayati Raj Institutions, Nehru Yuva Kendra Sangathan, National Service Schemes, Religious Bodies, Educational Institutions and these may be made trained for three phases of Disasters.

3 Flood relief preparedness plan of Haryana red cross

There is a Disaster Relief Preparedness Sub-Committee of Indian Red Cross Society, Haryana State Branch comprising Chairperson and 14 members. All the decisions for Disaster Relief are taken by the committee members in the meeting. Haryana is affected from two major disasters i.e. Flood & Drought besides accidents. Every year a contingency plan for flood preparedness is prepared by the Haryana Govt. Indian Red Cross Society sends the plan to District Red Cross Branches to coordinate with the assisting departments and to keep volunteers ready, para-medical staff, social workers, counselors, college & school youths and Brigade Divisions to meet the emergent situations. It is also given directions to the District Red Cross Branches to keep ready a list of First Aiders, Brigade Officers, and Blood Donors and to be in close contact with the Civil Surgeons of their respective district for medical/para-medical assistance. Haryana State Branch of the Indian Red Cross Society has three warehouses at Ambala, Rohtak & Gurgaon and a Relief Store at Chandigarh is being maintained by the State Headquarters. In these warehouses, the relief material is stored well in advance. The Red Cross State Headquarters, Chandigarh maintains a fund "Disaster Relief Corpus Fund". The interest earned from this fund is spent specifically for the victims of disaster. Haryana Red Cross has established Hospital Welfare Sections in all District Red Cross Branches to provide medical assistance and psychological support to the victims of Disasters so that any person affected from disaster may not feel helpless. Haryana Red Cross has also given instructions to all District Branches to enroll maximum lady social workers & to maintain the telephone numbers and address of these social workers so that at the time of emergency they may be contacted.

We are also trying our best to enroll all school going children, College & Universities students of the State of Haryana with Red Cross & St. John activities. The Youths can play vital role in disaster management by providing their voluntary services. So far we have 318 Brigade Divisions in the State and during the year 2009–10 we have trained 1,91,823 persons in First Aid and 78,955 persons in Home Nursing training of State. The volunteers of St. John can play vital to reduce the risk through awareness in the community by the following methods:

4 Risk reduction through community

In the earthquake prone areas, the masons should be given training to construct earthquake resistant buildings to minimize threat to the life of human beings during disaster. In the drought prone areas the farmers should be made aware about the water harvesting systems. The people residing in flood prone areas should be imparted training of water purification techniques to control the diseases after post disaster phases. Raised water storage structures should be made prior to floods in such areas for provision of potable (safe drinking water) during floods. A rescue team should be prepared of the trained First Aiders to utilize their services in rescue activities. The training & awareness should be created to prepare emergency shelters for the victims of disaster to the people at grass root level. The public should be made aware to reforestation by plantation. The people should be made aware about the environmental hazards by destructive impact of slash and burn agriculture. The people should be made aware to reserve amount to donate for the disaster affected people out of their pocket money.

5 Awareness campaigns

Awareness is most important component to reduce the disaster risk. To bring awareness the public, training programmes should be organized regularly. The public should be informed about the disaster and post disaster affects on the community. The First Aid training should be arranged for the response groups. The information should be disseminated through the photographs, films, posters and disseminating information on notice boards of the Schools/Colleges, Institutions, conveying information in telephone directories, shopping bags, banners etc. and by delivering lectures. St. John Ambulance provides training in First Aid & Home Nursing to the Schools, Colleges, Professionals, Drivers, Police Personnel, Home Guards as well as aware them about health & social issues. The Lecturers of First Aid & Home Nursing can play a tremendous role by educating the students & general public about the disaster management. It is the need of time to give this responsibility of public awareness to the St. John Ambulance as this is already making awareness in the community at large and has an International Setup.

Earthquake may cause multiple injuries and some medical problems like Heart Attack, Difficulty in Breathing, bleeding & shock. Record of trained First Aiders with the respective District & State Branch of the St. John Ambulance helps to utilize their voluntary services at the time of any disaster. A person spends a lot of money on building constructions, but due to lack of awareness does not follow the instructions of earthquake resistant building. This is main reason that earthquakes of less Richter scale destroy buildings and loss of human lives and property increases. Awareness in most important for the people residing in high risk zones as well as low risk zones.

6 Fast information system

The information about the coming disaster such as flood can be disseminated by the local persons by beating drums. Door to door message can be given, Latest methods of information such as internet, phone can be used. NGOs should prepare a team for this work and training for the team members should be organized and community based disaster preparedness plans should also be prepared so that the community may be made aware well in advance to reduce the risk of coming disaster. The volunteers of Red Cross & St. John can make the public aware about Do's & Don'ts to avoid fire hazards such as:

- To save from fire, faulty electrical appliances & old wiring should be replaced.
- At regular intervals fire fighting drills should be carried out for the common public.
- One socket should be used for one appliance only.
- In case of fire alarm, avoid using the lifts, use stairs only.
- Keep the house neat and clean.
- Keep LPG stoves on raised platform instead of the floor.
- After cooking, turn off the cylinder valve and burner.
- Avoid refilling a burning stove.
- To avoid friction in the machinery, keep it lubricated.
- Avoid smoking in prohibited areas.
- Electric installation should be carried out by a qualified electrician.
- Keep matches out of reach of children.

7 St. John ambulance in Haryana – preparing teams for disaster management

After the bifurcation of Punjab & Haryana, St. John Ambulance Association in Haryana came to existence since 1971. The main purpose of the First Aid & Home Nursing Training programme is to train the public to provide their services during any Emergency, Disasters and Accidents. To achieve this purpose following activities are being done by the St. John Ambulance, Haryana:

Every year First Aid & Home Nursing Training is imparted to the persons of the State. These trained persons can provide their services to hand the injured persons due to any accident and can utilize their services during any disaster/emergency. To form Brigade Divisions in the educational institutions, the members of the Divisions can be helpful for transportation of casualties and assisting the medical staff. Every year Lay Lecturers' Training Course in First Aid & Home Nursing is being organized. After completing the success training, these Lecturers impart First Aid & Home Nursing training to the students of Schools & Colleges, Workers of Industries, Police Personnel, Home Guards Personnel, Drivers, Conductors, Professionals and common public so that these persons can be helpful to support the Govt. at the emergent situation or Disasters. There are 175 Ambulances in Haryana State for transportation of patients with State Headquarters and District Red Cross/St. John Centres. All the ambulances are connected with GPS System being provided on 102 numbers by District Red Cross/St. John Branches in Haryana to the persons of Below Poverty Line, injured persons of road accidents, Institutional deliveries of pregnant women in hospitals and schedule tribes of slum areas free of cost and other people are availing the services on nominal charges.

8 Conclusions

It is a need to make a policy by the National Disaster Management Authority with the consultation of St. John Ambulance (India), National Headquarters, 1-Red Cross Road, New Delhi. President of India is the President of St. John Ambulance (India) at National Level, His Excellency the Governor at State Level and Deputy Commissioner/Deputy Commissioner at District Level. A clear cut guideline that the First Aid should be compulsory for all the citizens of India so that immediate First Aid can be provided to the injured persons should be prepared. The emphasize should be given on the vehicle holders either two, three or four vehicles as training of First Aid should be mandatory for these persons before issuing the Driving License like Drivers and Conductors of Transport Depts. The St. John Ambulance should be the Nodal Agency for imparting & evaluation of the Training Programmes. Thus we can reduce the risk reduction like fatal of the road accidents.

Keeping in view the International Network and trained man power, the National Disaster Management Authority should consider the services of St. John Ambulance and the services of the these trained First Aiders should be utilized for the nation building and to minimize the hazards of Disaster by creating awareness among the community at large.

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Disaster risk communication over early warning technologies - A case study of coastal Kerala

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Abstract

Disaster information may be delivered and disseminated in ways that increase its practical value to disaster risk reduction and management. Kerala has a long coastline with a length of 590 km which is vulnerable to various types of coastal hazards like storm surge, coastal flooding, sea erosion, tsunami, and cyclone. The impact of climate change can be manifested in these coastal hazards with the exposure sea level rise and other coastal hazards is expected its intensity to be severe in the coastal area of the state in the coming years. A proper disaster communication through various early warning techniques plays a crucial role to reduce disaster risk in the coastal area of the state. Timely prediction of the occurrence of most coastal hazards is almost possible at this point of time with help of advanced Information and Communication Technologies. Government of Kerala has established State-wide Early Warning System cum Communication Network with support of United Nations Development Programme (UNDP) under DRM Programme and Asian Development Bank (ADB) under TEAP Programme. The system is Very High Frequency (VHF) technology, well known for Alternative communication at all types of needs in disaster point of view. This may be most accurate technology in the state through to dissimilate warning to the vulnerable population in the hazard prone areas in general and coastal area in particular. Hence, Disaster communication over Early Warning Technologies can be a crucial part in a disaster risk management for the hazard prone areas of the coastal Kerala. This paper describes available opportunity to disseminating timely disaster communication over VHF technologies in a disaster situation to the vulnerable coastal region of Kerala.

1 Introduction

Disaster Communication and Early Warning system have been recognized as an integral part of disaster management for a long time. Disaster risk reduction and management requires effective and coordinated communication to avoid confusion and mayhem. Effective communication linkages between emergency operations centre, broadcasting system, and front-line responders and affected communities are critical role in the various stages of disaster management. Although disaster communication having an important role in all four distinct phases of disaster management namely, mitigation, preparedness, response and recovery. Right disaster communication thorough Early warning system with help of Information and Communication Technology helps disaster communication in a more systematic way. The state of Kerala has implemented Very High Frequency communication technology under last mile connectivity with support of UNDP and Asian Development Communication technology under for better emergency communication in the vulnerable area of the state.

2 Kerala coast and its vulnerability profile

Kerala has a long coastline of 590 km and prone to various types of coastal hazards like coastal erosion, storm surge, coastal flooding, high speed wind and projected sea level rise. The density of population is one of the highest in the country the average density of the coastal area is over 2000 per sq km. This long coastline is span across nine districts with unique physiographic like backwater, lagoons, estuaries, mangroves etc. Beside these diverse natural and physical features, the coast has a greater variety of concentration of economic activities, population, industry and infrastructure. As state coasts has for long time been economically attractive destination of modern agriculture, trade and commerce, industry and transport services.

Coastal vulnerability is a broad term that denotes the risk to various systems, such as human population, natural ecosystem, managed land use, human habitation and infrastructures, which are exposed to a variety of external coastal events. Coastal vulnerability, herein, in the state of Kerala, primarily refers to the vulnerability of human population and habitation exposed to various coastal hazards. The coastal areas in the state having dense population and concentrated various economic activities which is naturally prone to suffer higher damages. Under the unique physiographic condition of Kerala, the population density has tended to increase upwards the coastal region. Even the unstable coastline has not deterred large human settlement in close proximity to the sea. Out of the total are of 38,863 sq km of Kerala 3,355 sq km. falls in the coastal area supporting a population of 72.72 lakhs. The density of coastal urban population is 4,228 per sq km as compared to the average urban density of 2,097 sq km in the state.

The physical vulnerability is generated to various hazards like coastal erosion, cyclone, storm surge, coastal flooding, earthquake and projected sea level rise in many areas which has shown a multi-hazard nature of the coastal Kerala. Coastal erosion along the coastal areas is very frequent and severe, and 480 km length of the coast is under the threat of erosion. The rocky coasts with pocket beaches have minimum level of erosion. The coastal region of the state is subjected to unexpected flooding often without any warning due to sea borne processes like storm surges coinciding with high tide. Settlement in adjacent areas will be vulnerable to floods and scour. Almost 96.9% of the coastal area of the state lay in high wind- speed areas and is expected from the projected impact of cyclone in the future due to climate change phenomena. Annually in the south west monsoon period the most coastal area exposed storm surge and onshore wind. While most of them are natural events, their incidents are being affected by human induced changes. The tsunami on 26th December 2004 that struck the Kerala coast had added a new dimension to the hazard profile of the state as most of the low-lying and mid land areas in the state have an altitude of 4 to 6 meters only. Therefore physically and demographically, this area is more vulnerable than other parts of the state.

3 Disaster communication and early warning system

Communication is core to the success of disaster mitigation, preparedness, response and recovery. It is very relevant to deal effectively with disasters and to create disaster resilience. Communicating disasters — before, during and after they happen — is fraught with many challenges. Communication systems used in disaster situation are as effective as the quality of content they carry with them. Disaster communication and early warning have strong relationship to each other. One of the major objectives of disaster communication is give early warning about the risk to the particular disaster in an area. Early Warning help to reduce economic losses and mitigate the number of injuries or deaths from a disaster, by providing information that allows individual and communities to protect their lives and property. This information empowers people to take action when disasters close to happening. Effective early warning system embrace all aspects of emergency management such as risk assessment analysis, which is one of early warning systems design requirement, monitoring and predicting location and intensity of the natural disaster waiting to happen, communication alters to authorities and potentially affected, and responding to the disaster.

The effective application of these technologies in disaster communication through of Early Warning System depends greatly upon their appropriateness for the social and economic and geographic context in which they are applied. As a result, the possibilities for application of communication technologies in mitigation and prevention of disasters have also been increasing. The new communication technologies that have emerged over the last two decades lend themselves to greater possibilities of integration of disaster management. Television, print Medias, radio, web services etc are carried various disaster information and communication and disseminate it various sectors of life of vulnerable communities. But in a disaster point of view all these type communication techniques have some type of limitation. Because, disaster or emergency communication will most relevant thing in the light of its nature of that particular situation. Redundancy of communication system is essential for disaster management, while emergency power supplies and backup system are critical in order to avoid the collapse of communication system after disaster occurs. Information Communication Technology (ICT) tools enables us to be smart and strategic in gathering and dissemination of information.

4 Early warning technologies

Warning indicates the onset of a disaster for which a warning system is essential. The system may range from alarms, sirens to public announcement through radio, television etc and other traditional modes of communication. Early warning is the provision of timely and effective information, through identified institution, that allows individuals exposed to hazard to take action to avoid or reduce risk and prepare for effective response and is the integration of four elements.The aim of any early warning system is to provide warning to people of an impending natural hazard so that those vulnerable are aware of the potential impact of the natural processes in order to respond appropriately and minimize damage. The main goal of early warning system is to take action to protect or reduce loss of life or to mitigate damage and economic loss, before the disaster occurs.

An effective early warning system needs an effective communication system. Early warning disaster communication system are made of two main components (1) communication infrastructure hardware that must be reliable, especially during the natural disasters: and (2) appropriate and effective interaction among the main actors of the early warning process such as the scientific community, stakeholders, decision makers, the public and the media. The effective application of emerging communication technologies can be realized only if they from part of a sound early warning system based on well-established basic principle. In addition, in order to ensure reliable and effective operation of the communication system during and after disaster occurrence, and to avoid network congestion, frequencies and channels must be reserved and dedicated to disaster relief operation. Institutional cooperation framework is required for channeling information across reliable communication systems and cascades of interfaces for better response during disaster situations. Prediction, communication, and use of the information are necessary factors in effective decision making within the early warning processes. Prediction efforts by the scientific community alone are insufficient for decision making. A miscommunicated or misused prediction can result in costs to the society. The lack of clear and easy-to-use information can sometimes confuse people and undermine their confidence in public officials. In any case, clear and balanced information is critical, even when some level if uncertain rumors. For this reason uncertainty level of the information must be communicated to users together with early warning (Grasso V. F. *et al.*2007). An early warning could be useless if it were not able to get the community alert in the event of an upcoming disaster situation, further if it creates panic it would do more damage. Packaging of disaster information in various modes of communication such as personalized devices (such as mobile, telephone, email etc.), mass media (newspaper, radio, television) and community media (loudspeaker, hooter, alarm etc.) is necessary to ensure that desired objective is met.

5 Very high frequency early warning system in the Kerala

Tsunami was a turning point for disaster management activities in the state. It exposed existing weakness in disaster risk management and reduction initiatives of the state. Also, tsunami reminds us how disasters can make information infrastructure vulnerable which have very vital role in Disaster Management. When electricity, telephone and other communication services went down in the worst affected areas of tsunami, the state felt need of some strong network of communication and early warning technology for right dissemination of disaster risk of the vulnerable communities and areas. Reestablishment of communication of the event from the affected area is one of the important challenges in disaster management activities soon after tsunami. Based on the experience with Tsunami, where coastal communities had to lose their lives just because the information on the impending. Tsunami did not reach them on time, Government of Kerala started several steps for set up of early warning system for right disaster communication for getting vulnerable communities in the state from support of TEAP programme under Asian Development Bank and DRM programme under UNDP helped to installed early warning system in the state.. The system is Very High Frequency (VHF) technology, well known for Alternative communication at all types of need in a disaster situation in hazard prone areas of state in general and vulnerable coastal area in particular. This is a last mile connectivity technology which aims to build strategies around information, communication and community mobilisation in disaster preparedness and management in most vulnerable areas of the state. The basic objective of the exercise was last mile connectivity, meaning communicating an imminent hazard to the vulnerable community in the coastal villages.

By considering hazards and vulnerabilities exist in the coastal area of Kerala together with a view of reducing risk, it should be possible to increase the effectiveness within the institution, the efficiency of outgoing actions, and public preparedness for early warning system to be effective. Under the Revenue and Disaster Management Department, Government of Kerala, Early Warning system (EWS) Project, Push to talk – Very High Frequency radio system and a few additional equipments has been installed for Early Warning dissemination in the vulnerable coastal district. In order to strengthen the emergency response communication capabilities and early warning facilities of district administration and to enhance coordination between district administrations and village, VHF based Early Warning Systems were installed in vulnerable coastal villages in the state which spread across eight coastal districts. Through this the state must be benefited early warning to the public and effective response and coordinated relief well in time to protect human life, property and environment.

6 Objectives of the project

- Strengthening disaster preparedness and emergency response capabilities of the state.
- To minimize the loss of life and property in the state though effective disaster early warning and effective emergency response coordinating system
- To strengthen the district emergency response capabilities through radio communication system installed in district collectorates/Taluk offices/village offices
- To develop a proper Early Warning System for strengthening preparedness for Disaster

6.1 Pre-requisite for implementing early warning system in Kerala

In order to gain a comprehensive participation of people into the Installation of Early Warning System in various vulnerable location, understanding village dynamics, and the challenge and aspiration of vulnerable community group, Revenue and Disaster Management, Government of Kerala , meeting and process various phases during the execution of the project. They are the following

Phase 1 - ***Identification of the vulnerable villages by assessing the vulnerabilities/risks:*** One of the vital information requirements for the establishment of Last Mile Connectivity system is the identification of the most vulnerable locations. The locations were identified based on physical and social vulnerabilities and also based on either the past disaster-damage data base or experience of the district authorities or community.

Phase 2 - ***Finalization of a communication technology by studying various technical options:*** This was done through consultation meetings with Government authority and Technical stakeholders. A range of technologies suitable for Early Warning Systems (EWS) were studied and demonstrated. Wireless radio based communication technology was found to be the most suitable technology.

Phase 3 - ***Building of capacities of the stakeholders to receive and respond to alerts/warnings/disaster related communication:*** It has identified few NGOs to implement capacity building programmes at the vulnerable villages, where the EWS is setup. The programme enable the community members get acquainted to the Early Warning Systems, set up in their village and also get trained on the response (to early warnings) strategies. Capacity building programmes included awareness generation on risks and vulnerabilities, significance and application of early warning systems, response (to early warnings) strategies, monitoring and maintenance of the EWS equipments and essentials of EWS network and its functions.

Phase 4 - ***Promoting a structure to sustain the programme:*** A network of Non-government organizations, community based organizations, Panchayati raj institutions and government departments are being formed to ensure functioning of the system. The network will organize periodical mock drills to ensure functioning of the system and facilitate practice of response strategies by the stakeholders.

Based on the above said criteria's around 245 vulnerable coastal villages are selected for the early warning system installation in the state covering nine coastal districts.

Table 1. EWS installed vulnerable villages in Kerala.

Districts	**No of vulnerable taluks/villages offices**
Trivadrum	35
Kollam	43
Alappuzha	26
Ernakulam	26
Thrissur	24
Malappuram	14
Kozhikhode	20
Kannur	26
Kasarghode	20
Total	234

Criteria for selection for villages:

- Villages lying very close to the sea (2–3 km) or surrounded by sea and back waters
- Villages with comparatively high population
- Villages affected by coastal erosion, cyclone, tsunami or other disasters in the past
- Any Village identified as vulnerable to disasters (Sea & Climate related) by scientific institutions.
- Total coverage (spatially equi-distant) of the district may also be considered.

Department of Revenue and Disaster Management, Government of Kerala recognized the need to facilitate the community's participation in the development process of Early warning System and Disaster Risk Management, strongly believe that community involvement in these system development processes is a non-negotiable prospect. So in the state, 360 selected Vulnerable Villages in these 14 districts have been connected EWS network among these 250 are vulnerable villages in the coastal area covering 9 districts in the state.

6.2 EWS installed vulnerable villages in the state

An alternate early warning system - 234 vulnerable coastal villages are now connected to the District Administration in EWS frequency, where two way communications is possible using VHF Radios with Public Addressing system in case of emergencies (Table 1). Apart these, all most all the vulnerable villages in the state were being EWS equipments set up.

6.3 Disaster communication and early warning in coastal Kerala

Coastal area of the state is prone to various types of coastal hazards and obviously it is more vulnerable than other parts of the state. Many vulnerable communities especially fishing communities are living very near to coast and they are exposed to different type of disaster risk due to various types of disasters. Very High Frequency based early warning technology is an appropriate technology to disseminate disaster information to these vulnerable communities and thus reduce risk of the people whose more are exposed to various types of coastal hazards. The benefit is that it may reduce risk of existing in the area and strengthen capacity of the local people by giving right warning and disaster information to the right time. In fact, the review of existing early warning system shows that in most cases communication system and adequate response plans are lacking.

Exclusive and authorized government agencies make predictions on impending disasters and communicate the alerts/ warnings to the designated authorities (MHA/ IMD/CESS, GSI etc). The challenge is basically communicating such alerts/ warnings to the last mile community (Table 2).

6.4 Communication network

The wireless radio system offers free flow of communication between state control room and district head quarters and between district head quarters and village officers/taluk officers. The disaster alerts and warning received from varoius agencies (IMD, Centre for Earth Science Studies, GSI,) to State Control Room and this can be disseminated to all or preferred District Collectores or District Control Rooms through Wireless Network. At the district level, district collector or district control room can disseminate alerts or warning to one or more villages selectively by using particular village-specific radio codes. The wireless Radios in village Officers are also connected to Public Address System through amplifier that is set up on the top of the officers in order to facilitate dissemination of early warning directly from the desk of district collector to the vulnerable communities which amplifies the voice received and makes it audible to people at distance of 1km to 1.5km in radius from the source. . Thus, the system enables the district collector to issue warning from the district collectorate directly to the vulnerable communities. Besides, the District collector from his office can also trigger the siren at the village through the Public Adressing system and also communicate the warning intended to the village. Thus the VHF-PA integration enables the vulnerable community has direct access to the authenticated source of information.

Other than disseminating warning, the system can also be utilized for regular official communication between State Control Room and District Headquarters and between district headquarters and village officers/taluk officers. This would also be facilitating in coordinating response and relief in the event of a disaster. Monitoring and prediction of disaster risk of vulnerable communities is most important basic element for good early warning in the state. This step provides the input information for the early warning process that needs to the disseminated to those whose responsibility is to respond. In the state, various agencies like scientific organizations, governments departments, Research and Developments (R&D) to give to monitor and prediction of disaster risk or chances of occurrence of event to the communities. The major responsible agencies in these groups are State Disaster Management Authority, Indian Meteorological Recourse Centre, Revenue and Disaster Management Department, Centre Earth Science Studies, Geological Survey of India etc.

6.5 Major commands used

There are various standard procedures for the communication which is very mandatory the Early Warning Project. The adoption of standard formats for disseminating and exchange information has to be promoted. The advantage of standard format alerts is their compatibility with all information system, warning system. The adoption of standard formats guarantees consistency of warning message and is compatible with all types of information system and public alerting system. It is a one way bridge communication ie both users cannot cross or talk at a time for the communication. Communication is happens from one side only other user must receive the message without any interruptions. Also at a time user can make message with 60 seconds only after automatically it will be disconnected from path. If user want continue message he/she must again starts same procedures to disseminate message. After disseminating message to other ends of communication user much say over message has been delivered and he can wait for the replay from other side (Fig. 1)

6.6 Process involved for delivering of early warning information to the vulnerable coastal villages

1. The Emergency messages will be received by State Emergency Operation Center and will be disseminated to District Collector or Emergency Operation Centre (DEOC) situated at each District headquarters, through VHF Radios, phones, email etc.

2. From District Collector or District Emergency Operation Centre the emergency messages can be disseminated to each community through VHF-Push to Talk Radio system. These Vulnerable communities in each of these Districts have been identified by the District Administration. Now, all of these selected coastal Village offices have this facility, through which message can be disseminated directly to Public immediately at anytime (24×7).

3. In DEOC, a directory of Village-specific Radio Codes is available; using which message dissemination to one or more villages can be done immediately through EWS channel (Allocated frequency for EARLY WARNING SYSTEM).

4. In each of these Community the VHF - Push to Talk Radio system have been attached to a Local Public Address System, which amplifies the voice received and makes it audible to people at distance of 1km to 1.5km in radius from the source.

5. Each community will have a radio codes or Radio Number, which are like XYZ.

6. Each district is primarily divided into Taluks or clusters for easy communication, a set of communities that falls in the Taluk will have X digit in common.

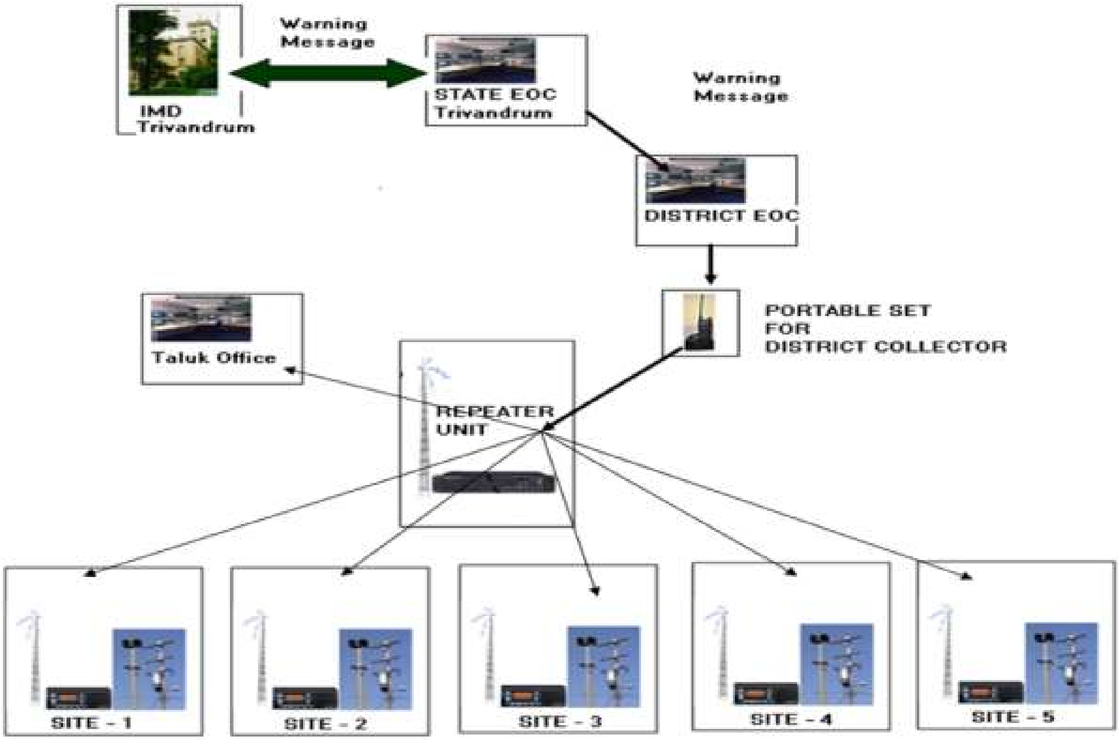

Figure 1. Communication Flow Network.

Table 2. Coastal Hazards in Kerala and responsible agencies for monitoring and predicting.

Disaster	Agency
1. Floods	IMD, Irrigation department, CWC, Revenue & DM Department
3. Tsunami	INCOIS, Revenue & DM Department
4. Cyclone	IMD, Revenue & DM Department
5. Epidemics	Health department, Revenue & DM Department
6. Landslides	CESS, Revenue & DM Department
7. Sea Erosions	CESS, Revenue & DM Department

7. From EOC, if a particular block has to be alerted, then one has to push the microphone head and simultaneously press AAAX in the dial pad of VHF-Push to talk Radio system.

8. From EOC, if a particular community has to be alerted, then one has to push the microphone head and simultaneously press XYZX in the dial pad of VHF Push to talk Radio system.

9. After pressing these numbers, the one will have to leave the Microphone head for 30 seconds.

10. As soon as the one leaves the microphone head, an acknowledgement tone is noticed (like a small. . . peep)

11. These 30 seconds are the time for siren alarm at the other end (receiving end).

12. Now the Emergency message can be vocally delivered, by pushing the Microphone head of the VHF-Push to talk system.

13. The Receiving end should not interrupt by pushing the Microphone head of his system.

14. Rather one has to wait, till the person at other end tells "Over" and then he can talk back to him by pushing the Microphone of his system for confirming the receipt of Warning Delivered

6.7 Challenges

Last mile connectivity of disaster communication is possible in the state but still it facing some challenges for useful manner. Timely coordination among various state level agencies and with district and village level for disaster communication is still an important challenge. A frequent problem, however, is the key linkage between the technical capacity to issue the warning and the capacity of the warning to trigger the appropriate response by emergency management agencies and the public at large. Moreover, the understanding by the coastal communities of their risk and vulnerabilities is often lacking. Therefore, preparedness programmes as well as public education and awareness programmme are needed.

Technically many complaints exist with Early Warning System projects in the state. In long term objective, strong technical capacity must develop for rectifying future complaints related to the early warning in the state. In particular the action need to be taken to improve prediction capabilities for various coastal hazards aiming at the development of these early warning system which is currently not yet in place. An institutional mechanism to regularly monitor and communicate slow-onset changes is needed to keep changes under review and to enable rational and timely decision to be taken based on improved information. Also community is the first responder to any kind of disaster warning, but its response can be made more effective by inculcating the culture of preparedness into their minds to lessen the impact of disasters. Hence, capacity building of the local community is the needed for better response

7 Conclusion

The new communication and information technologies that have emerged over the last two decades have led to the greater possibilities of integration with Early Warning System. The implementations of this in the state vulnerable areas have become an added advantage for various activities to disaster risk reduction and management activities in the state. In a long term run early warning system strategy implemented in Kerala will be finest tool to reduce projected climate change risk in the state. It has already strengthened vulnerable coastal population in the state by reducing existing risky condition. Despite some limitation for the proper communication using over VHF radio, last mile connectivity project is best available technology for proper disaster communication as well as disaster reduction and management. The using of Last mile connectivity techniques will be expected to a make a proper communication of disaster risk among various levels

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Fluoride contamination in groundwater resources of Chittur block, Palghat district, Kerala, India - A health risk

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ABSTRACT

Groundwater with high fluoride content is reported from Chittur block, Palghat district, Kerala, South India. Chittur block represents a mid land region of Palghat district with an area of 261 sq km and is categorized as over exploited area. The study area differs from the rest of the district in its climate and is a rain shadow region with an average rainfall of 1500 mm. Palghat district represents a hard rock terrain in which weathered crystallines, laterites, alluvium form the phreatic aquifers, and deep fractures in the crystallines form the semi-confined and confined aquifers. Hydrogelogical investigations along with sample collections have been carried out to identify the fluoride affected area and to demarcate its spatial extent. 50 observation wells were established for water level and quality monitoring. 50 groundwater samples were collected from different geological units covering the entire geographical area of the block. Chemical analyses have been carried out in the department of Geology, University of Kerala. The results have been correlated with various factors. Form the study it is found that both phreatic and deeper aquifers have high fluoride (F^-) and the concentration ranges from 0.2 to 5.75 mg/l. Fluoride content of ground water originates from the dissolution of the fluorine bearing minerals from the bed rock. Low amount of fluoride (0.3-1.0 mg/l) in drinking water helps in the prevention of dental caries and osteoporosis. However, high intake of fluoride (>1.5 mg/l) in drinking water for a prolonged period can damage the teeth enamel and eventually lead to skeletal complications which ultimately can result in fluorosis. Dental fluorosis observed in the study area. The spatiotemporal variation of F^- content in ground water and its relation with geology, depth and types of well and hydrochemistry of water were studied and the data are processed on a GIS platform. Various layers digitized and attribute tables were prepared. ARC GIS 9.1 is used to study the spatial distribution of F^- concentration in groundwater and its temporal variation. Different thematic layers were prepared. The geospatial analyses results has revealed that the fluoride content in the groundwater has a strong bearing with geology , mineral assemblages, rock water interaction and climate of the region. The other factors have negligible role in shaping the groundwater chemistry of the region. Temporal variation of F^- concentration is also noticed in the area. Since groundwater is the major source for drinking purposes, remedial measures are very much essential in the area. Detailed investigations are being carried out by the authors.

1 Introduction

Groundwater with high fluoride content is reported from Chittur block, Palghat district, Kerala, South India. The location of the study area lies between N latitude 10°37′40″ and 10°48′59″ and E longitude 76°41′25′ and 76°54′32′ and is shown Figure 1. Chittur block represents a mid land region of Palghat district with an

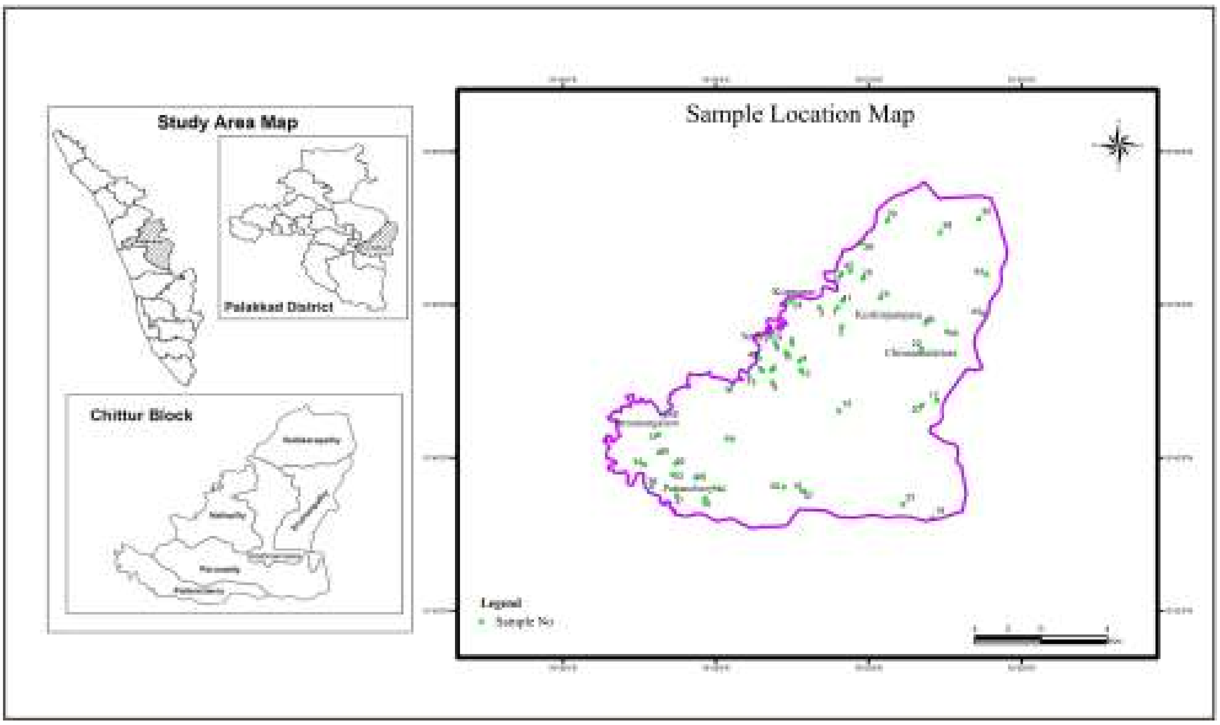

Figure 1. Location map of the study area.

area of 261 sq km and is categorized as over exploited area. The study area differs from the rest of the district in its climate and is a rain shadow region with an average rainfall of 1500 mm. Palghat district represents a hard rock terrain in which weathered crystallines, laterites, alluvium form the phreatic aquifers, and deep fractures in the crystallines form the semi-confined and confined aquifers. Geochemically, fluorine is the most electronegative element and occurs primarily as a negatively charged ion in water (Hem 1985). Fluorides, as with a number of other trace elements (e.g., iodine, selenium), can therefore be considered as harmful or beneficial to humans and animals (Dissanayake 1991; Ozsvath 2009) depending on the amount ingested on a daily basis. Some hydrochemical conditions that favor the dissolution of fluorine from silicates include an alkaline pH, anion exchange (OH- for F-) capacity of aquifer materials, cation exchange capacity (Na^+ for Ca^{2+}), long residence time of water in a water rock interaction system, and climate (e.g., Boyle1992; Saxena and Ahmed 2001; Ozsvath 2009). Trace elements are essential and beneficial for human body in minute concentrations, as they play an important role in many metabolic processes. However, excess intake of certain trace elements can have adverse effects on general body metabolism. One such trace element is fluorine, in the form of fluoride, which is ubiquitously distributed in soil, earth and water. It is known that low amount of fluoride (0.3–1.0 mg/l) in drinking water helps in the prevention of dental caries and osteoporosis. However, high intake of fluoride (>1.5 mg/l) in drinking water for a prolonged period can damage the teeth enamel and eventually lead to skeletal complications which ultimately can result in fluorosis (WHO, 1984; ISI, 1983). Thus fluoride (F^-) concentration is an important aspect of hydrogeochemistry. Hence, it is essential to have a safe limit of F^- concentration of between 0.60 and 1.20 mg/l in drinking water (ISI 1983). Moreover the Bureau of Indian Standards (BIS, 1991) has prescribed a limit between 1.0 and 1.5 mg/l of F^- in drinking water. High fluoride is reported from both phreatic and deeper aquifers in the eastern part of Palghat district (Shaji *et al.*, 2007).

2 Materials and methods

Hydrogeological investigations along with sample collections have been carried out to identify the fluoride affected area and to demarcate its spatial extent. 50 observation wells were established for water level and quality monitoring. 50 groundwater samples were collected from different geological units (Figure 1) covering the entire geographical area of the block. Which include 40 dug well samples and 10 bore well samples. Chemical analyses have been carried out in the department of Geology, University of Kerala. Fluoride analysis carried out in an instrument -Spectroquant nova 60. The chemical analyses data of selected wells are given in the Table 1. In this fluoride analysis method sample make into a buffered, weakly acidic solution, fluoride ions react with alizarin complex one and lanthanum (111) to form a blue complex that is determined photometrically. Sodium ion determined in the Flame Photometer and calcium concentration determined by titration. The results have been correlated with various factors. Form the study it is found that both phreatic and deeper aquifers have high fluoride (F^-) and the concentration ranges from 0.2 to 5.75 mg/l. The EC value ranges from 464 to 2750 during April 2010 and 337 to 2570 microseimens/cm at 25° C during August 2010, TDS values ranges from 239 to 1420 during April 2010

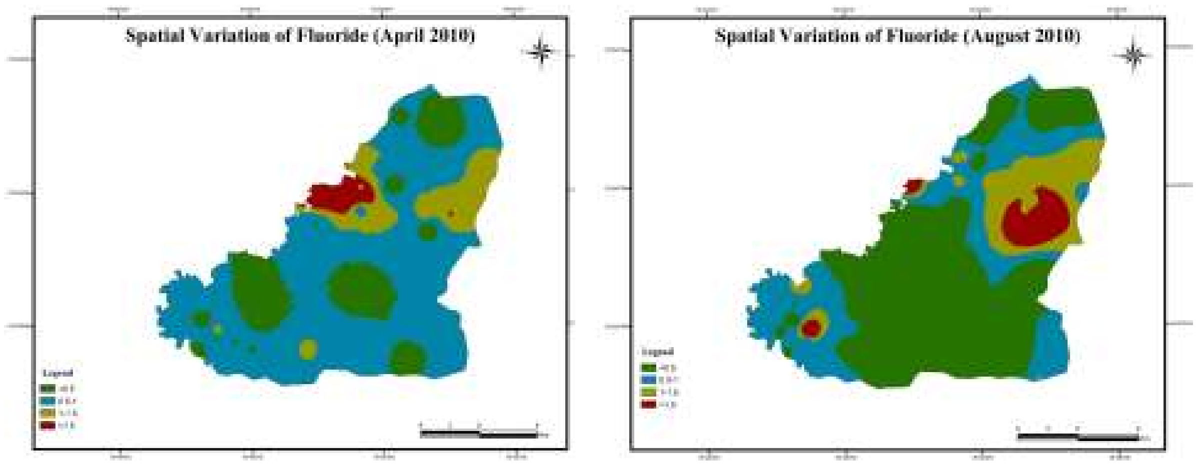

Figure 2. Spatial Variation of Fluoride in April and August.

Table 1. Chemical Analysis data of selected groundwater samples.

	Fluoride (mg/l)		EC (μS)		TDS (ppm)		Salinity (ppt)		Calcium (ppm)		Sodium(ppm)		pH	
SI No:	April	August	April	August	April	August	April	August	April	August	April	August	April	August
1	1.79	0.6	464	337	239	181	0.29	0.22	40.08	6.01	36	36	6.94	7.05
2	1.16	1.42	2750	2570	1420	1380	1.72	1.68	50.1	38.08	126	129	7.18	7.75
3	5.75	3.1	2050	1590	1000	850	1.23	1.04	40.08	34.08	81	122	7.74	7.92
4	1.24	3.3	464	940	239	505	3.29	0.62	28.06	36.07	54	102	6.95	7.61
5	0.9	0.77	315	1320	474	710	0.58	0.87	32.06	38.08	61	92	7.02	7.52
6	1.3	1.32	1540	1720	770	920	0.94	1.12	36.07	38.08	45	112	7.53	7.78
7	1.42	1.15	1440	1380	720	740	0.87	0.9	32.06	30.06	41	96	7.54	8.21
8	1.24	1.4	1020	1030	510	554	0.62	0.78	34.07	22.04	29	63	7.44	8
9	1.16	0.83	1530	816	770	436	0.93	0.53	86.17	38.08	37	61	7.87	8.52
10	1.53	1.92	1510	1430	760	770	0.92	0.94	86.17	30.06	31	81	7.58	7.9

and 181 to 1380 ppm during August 2010, Salinity values ranges from 0.29 to 3.29 during April 2010 and 0.22 to 1.68 ppt during August 2010, calcium concentration ranges from 28.06 to 86.17 during April 2010 and 6.01 to 38.08 ppm during August 2010, sodium value ranges from 29 to 126 during April 2010 and 36 to 129 ppm during August 2010 and pH value ranges from 6.94 to 7.87 during April 2010 and 7.05 to 8.52 during August 2010. Geographic information system (GIS) has been used to integrate the data. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. The spatiotemporal variation of F^- content in ground water and its relation with geology, depth and types of well and hydrochemistry of water were studied and the data are processed on a GIS platform. Various layers digitized and attribute tables were prepared. ARC GIS 9.1 is used to study the spatial distribution of F^- concentration in groundwater and its temporal variation. Different thematic layers were prepared.

3 Discussion

The geospatial analyses results has revealed that the fluoride content in the groundwater has a strong bearing with the water chemistry, mineral assemblages, rock water interaction and climate of the region. Palghat district represents a hard rock terrain. Spatio-Temporal variation of fluoride has been analyzed in various seasons (April and August). Temporal variation of F^- concentration is also noticed in the area. High fluoride detected in the northwestern and eastern part of the study area near the Palghat gap.

The spatial variation of fluoride in April and August 2010 is given in Figure 2. Groundwater with high content of fluoride is reported from many parts of the study area. In the pre monsoon (April) period fluoride concentration is high in western part of the study area and in post monsoon (August) fluoride concentration high in eastern part. During post monsoon period the fluoride concentration shows a declining trend due to dilution. The variation may be due to the influence of rainfall infiltration and the influence of canal water.

4 Conclusion

From the study, it is found that both phreatic and deeper aquifers have high fluoride (F^-) and the concentration ranges from 0.2 to 5.75 mg/l. High concentrations are observed during pre-monsoon period (April). Decrease in concentration during post monsoon has a bearing with rainfall and canal water irrigation. The geospatial analyses results have revealed that the fluoride content in the groundwater has a strong bearing with geology, mineral assemblages, rock water interaction and climate of the region. The other factors have negligible role in shaping the groundwater chemistry of the region. Temporal variation of F^- concentration is also noticed. Dental fluorosis noticed in study area especially among children. Fluoride concentration is positively correlated with sodium and pH and negatively correlated with calcium. Since groundwater finds major source for drinking purposes, remedial measures are very much essential in the area. Detailed investigations are being carried out by the authors.

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Groundwater quality of Kerala – Are we on the brink?

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ABSTRACT

There is growing concern throughout India about the contamination of groundwater as a result of geogenic and human activities. In India, groundwater resources are being utilized for drinking, irrigation and industrial purposes. The groundwater is estimated to provide about 80 percent of water for domestic use in rural areas and about 50 percent of water for urban and industrial areas. With the rapid growth in population, urbanization, industrialization and other developmental activities, groundwater resources have become vulnerable to depletion and quality degradation. The causes of groundwater contamination include use, spillage, or disposal of pesticides, fertilizers, petroleum hydrocarbons, industrial chemicals, and waste products. The contamination can also result from geologic sources and changes in the existing land use. The importance of groundwater as a resource to the nation cannot be overstated. Kerala is strongly dependent upon groundwater and has considerable value both for its economic and social uses (i.e. drinking water, water supply system, agriculture, industry, and recreation), and for its role in maintaining a range of ecosystems at the surface and below ground. The contamination of groundwater can have adverse effects on these uses, ultimately leading, as water quality deteriorates, to the groundwater being unable to support or maintain these beneficial uses. In most cases this degradation is irreversible. Remediation is very expensive and is often unsuccessful. Consequently, adequate protection of groundwater quality must be a primary aim. Groundwater and surface water are often closely linked, and changes to quality or quantity in one resource frequently creates an impact on the other. Groundwater contributes to streams, lakes and wetlands, and is particularly significant in maintaining these surface water ecosystems in dry periods. Furthermore, surface water quality can affect groundwater quality through seepage and where surface water directly enters groundwater. Protection of surface water quality is often considered to be of paramount importance because impacts of contamination or poor water quality are readily observed. However, given the value of groundwater to the nation and the connections between surface water and groundwater, protection of the quality of groundwater should be given at least equal prominence to that of surface water. Additionally, there is a need for a greater awareness of groundwater, its key role in supporting a range of economic, social and environmental values, its significance in the hydrological cycle, and the need to protect these valuable but invisible resources.

1 Introduction

Groundwater is one among the Nation's most important natural resources. It is one of the major sources for drinking water, agriculture, industry, as well as to the health of rivers, wetlands, and estuaries throughout the country. Large-scale development of ground-water resources with accompanying declines in ground-water levels and pollution has led to concerns about the future availability of ground water to meet domestic, agricultural and industrial needs (Datta, 2005).

Kerala State lies as a narrow strip of land along the southwest corner of India bordered by Western Ghats on eastern side and Lakshadweep Sea on the western side. The State lies between the North latitudes 8° 18′ and 12° 48′ and east longitudes 74°52′ and 77°22′. The State has been divided into 14 districts and 152 blocks. Though the State is blessed with plenty of water resources and rainfall, the availability of water resources, especially groundwater is not uniform through out. It varies from place to place. The State has varied hydrogeological and geomorphological characteristics and hence the groundwater potentials differ from place to place. Increasing urbanization and growing dependence on groundwater for irrigation and industry has called for judicious and planned exploitation of the groundwater resources. For proper planning and management of groundwater development quantification of groundwater resources is one of the most important prerequisites.

In Kerala, nearly two decades ago, groundwater exploitations were restricted to unconfined aquifer through dug wells. In fact, common man then had enough knowledge to construct wells in the valleys since valley portions are the repository zones of groundwater. The effluent water table conditions had then enabled water flow in the drainages even during lean season. Presently with the advent of technology ,high-speed rigs and quality deterioration of surface water have resulted in uncontrolled exploitation of groundwater resources. Little measure has been taken by the government machinery and other departments to contain the unprecedented over-draft and to bring in measures to revive the depleted groundwater resources. Now new initiatives are in force to educate the people. But it is not an easy job to restrict over-exploitation of groundwater. In many places, supply of groundwater became a lucrative business. The free and or subsidized power supply policy further aggravated the condition. There is now a ‘free for all’ situation as far as groundwater utilization is concerned. There is considerable change in land use pattern and agricultural practice of the state. The area under paddy has declined from 801700 hectares (ha) in 1980–81 to 289974 ha in 2004–05, where as the area under commercial crops, rubber and coconut has increased considerably during the last two decade. The area under rubber has increased to 480661 ha in 2004–05 from 237800 ha of 1980-81. Similarly the area under coconut has increased to 899267 ha in 2004–05 from 651400 ha of 1980–81 (CGWB,2006).Groundwater development and its environmental implications like, over exploitation, decline of water levels, quality deterioration, sand mining, seawater ingress, spacing of wells with septic tanks/sewerage pits, change in land use, poor sanitation, water logging and climate change are to be studied in detail.

2 The environmental/quality issues and groundwater in Kerala

The environmental/quality issues associated with groundwater development are discussed below.

2.1 Effects of overexploitation on groundwater regime

The over extraction of groundwater i.e. excessive withdrawal beyond the normal recharge in any given area creates many harmful effects which could be identified as:

- Continuous lowering of water levels. (Both pre-monsoon and post- monsoon)
- Lowering of pump sets, causing low efficiency, higher cost of operation
- Reduction of yields of wells, well interference due to close spacing of wells, severe drinking water scarcity in summer months.
- Deepening of wells and increase in cost of groundwater extraction
- Damage to aquifers due to compaction, risk of ground subsidence due to inter-relationship between withdrawal and downward trend in water levels due to overdraft conditions.
- Total collapse of operation & management system of groundwater resource of the basin or watershed and disturbed planned and sustained development and regulatory system in the area.

2.2 Decline in groundwater levels

The analysis of decadal water level trend (1996–2005) indicates that 13% and 30% of monitoring wells are showing declining trend of more than 0.1 m/year for pre-monsoon data and post-monsoon data respectively (CGWB 2005 and Shaji *et al.*2009). The water level decline during post monsoon period is attributed to base flow, higher groundwater development for various uses and change in land use pattern. Similarly the piezometric head of Tube wells in Alleppey town show a decline trend. Since these tube wells are being pumped continuously for urban water supply this may leads to some environmental problems like land subsidence (CGWB (2005).

Lowering piezometric head is also noticed from Chavara industrial area. Detailed studies are required in these areas.

2.3 Quality deterioration

In general, the quality of the shallow groundwater in Kerala State is good. Incidence of high fluoride in reported from Palghat and Alleppey district. In Palghat district high fluoride is reported from deep sedimatery aquifer whereas in Paghat it is noticed in crystallines. The dug wells Plaghat are showing fluoride in the range of 0–5.75 ppm. The higher value is recorded from Kopanur (5.75 ppm). The bore wells are showing high concentration of fluoride, ranging from 0.3 to 3.12 ppm. The highest concentration is reported from Chinnamoolathara (EW of CGWB). The water supply from bore well of Eruthanpathy also shows 1.76 ppm of fluoride (Shaji *et al.*, 2007). This shows that in the eastern part of the district, fluoride concentration more in both phreatic and deeper aquifers. Fluoride contamination in Alleppey district is reported from the samples collated from tube wells with a maximum value of 2.56 mg/l.

Higher content of nitrate and iron is reported in groundwater in many parts of the state. Bacterial contamination is being reported from all districts in dug wells and is growing in alarming stage.

2.4 Problem associated with fresh water lakes

Vellayani is one of the three rainfed freshwater lakes in Kerala, the other two being Sasthamkotta lake in Kollam and Pookkode lake in Wayanad. Sasthamkotta Lake is in news recently on account of waste dumping (James, 1999). Ravaged by pollution and land reclamation, the Vellayani freshwater lake here is facing a fresh threat to its existence from illegal extraction of sand in the fallow paddy fields along its periphery. Truckloads of sand are being removed daily from the vast lowland fields that were reclaimed from the lake by local farmers for paddy cultivation.

3 Sea water ingress

Kerala has about 600 kms long coast line. Coastal sedimentary formations are seen all along the Kerala coast but the prominent area lies between Ponnani in Malapuram district and Veli in Trivandrum district. Geomorphologically, the area is dissected by numerous rivers, backwater channels and lakes. In two areas namely Kuttanadu and Kole altitude of land surface lies below mean sea level. The shallow aquifers tapping the coastal alluvium are generally fresh with isolated pockets of saline water developed during summers close to the backwater channels, lakes and the tidal rivers.Amongst the Tertiary beds the aquifers in Vaikom beds hold fresh water to the south of Karuvatta in Alleppey district. The source of salinity in the Tertiary aquifers was studied in detail by CGWB. The salinity/brackishness of groundwater is due to leaching of salts from the aquifer material (insitu) and not due to sea water intrusion. Sea water ingress to the coastal aquifers due to over extraction is not reported from the Kerala Coast. However salinity is noticed in shallow wells close to the backwaters, lagoons, lakes and the tidal rivers. The rivers of Kerala often encounter salinity intrusion into their lower stretches during summer months. When the fresh water flow reduces, two major problems are encountered in these water bodies (i) salinity propagates more into the interior of the river (ii) flushing of the system becomes less effective. Both these have an impact on groundwater based water supply wells and other wells situated close to the rivers. Problems of salinity intrusion are also encountered in Bharathapuzha, Periyar, Meenachil and Kuttiyadi rivers. The extensive sand mining in river beds may further damage the system.

3.1 Pollution of groundwater bodies

Kerala is one among the most thickly populated state in India. As a result of the measures to satisfy the needs of the huge population, the rivers, ponds, wells, tanks and streams of Kerala have been increasingly polluted from the industrial and domestic waste and from the pesticides and fertilizers. Industries discharge hazardous pollutants like phosphates, sulphides, ammonia N, fluorides, heavy metals and insecticides into the water bodies. Recent trend is much alarming ie. depositing the chemicals from factories, E-waste (computer waste) and other biological wastes (chicken waste) in open wells and ponds.

3.2 Bacteriological contamination and poor sanitation

Open dug wells are important groundwater extraction structures in the coastal belt of Kerala and groundwater is the most common source of drinking water in these areas. In general, groundwater quality of Kerala is very good. Of late, these precious resources are getting contaminated by various effluents and anthropogenic activities. Open wells of Kerala have the problem of bacteriological contamination and studies have shown that faecal contamination is present in 95% of drinking water wells. This could be due to poor or poorly maintained sanitation facilities. Majority of the population have access to piped water but only some have proper sanitation facilities.

3.3 Water logging

Another local ground-water problem is water logging. Water logging has developed in some areas because of excess application of irrigation water obtained from surface-water sources.water logging is commomn in Kuttand and Kole land areas. In other areas, natural water logging problems have been intensified by irrigation practices. Water logging in the commands of major and medium irrigation projects is a known problem. According to the studies conducted by CWRDM, around 400 Ha of land in the commands of Malampuzha and Kuttiyadi irrigation projects are water logged. Water logging is due to (i) high density of irrigation (ii) wrong and defective methods of irrigation (iii) improper maintenance of nature channels (iv) hydraulic pressures from saturated areas at higher elevations (v) heavy seepage losses from canals (vi) absence of drainage canals in irrigated areas (vii) silting Pollution of water bodies

3.4 Problems associated with pesticides and insecticides

Numerous studies over the past four decades have established that pesticides, which are typically applied at the land surface, can move downward through the unsaturated zone to reach the water table at detectable concentrations. The downward movement of pesticide degradation products, formed in situ, can also contribute to the contamination of ground water. Once in ground water, pesticides and their degradation products can persist for years, depending upon the chemical structure of the compounds and the environmental conditions. We have now problems with endosulfan etc

3.5 Groundwater quality management plans

Groundwater quality protection should be pursued through an approach that is based on the beneficial use concept and implemented through an integrated approach, utilising a range of measures, including the key measures of:

- risk and vulnerability assessment;
- land use planning and management;
- regulatory measures (e.g. licensing)
- economic and market mechanisms (e.g. trading)
- human, financial and technical resourcing
- institutional arrangements
- availability of appropriate regulatory tools
- appropriate economic and market mechanisms
- community awareness and education

The approach should also account for managing interactions between water quality and quantity and between surface and groundwater. In the development of groundwater management plans, strategies to protect groundwater from contamination and maintain its Beneficial Use (including ecosystem values) should be included.

The effectiveness of groundwater quality management and protection relies on enforcement and a comprehensive, targeted monitoring program. Since monitoring often must be undertaken over the long term, it often suffers budget cuts or is neglected due to lack of resources. However, if baseline trends are not known, early response to potentially adverse impacts is not possible. Monitoring is a key activity to enable identification and protection of groundwater from pollution.

4 Conclusions

Traditionally dug wells met the drinking water needs and rivers, streams and ponds met irrigation and other needs of rural people in the state. Urban populace mainly depends on piped water supply (surface water) for their needs. Now after introduction of piped water supply to the rural area, the old Panchayath wells and other water bodies are being neglected. Groundwater below the land surface being invisible, the common man could not judges its availability in terms of the depth to groundwater table and quality. Their demands on land and groundwater and the consequences of these demands have been characterized scarcely. Due to absence of any pricing mechanism and strict regulation, indiscriminate groundwater exploitation, its wasteful utilization, and land disposal of wastes continued. In Kerala, We wake up in our homes and walk to the toilet, brush our teeth, sink and bath. We use lavish water (treated water) for cooking, washing clothes, gardening and car washing. In much of the world, however, this is not the routine. Daily life is marked by a lack of access to drinking water, sanitation and hygiene resources. Presently groundwater resource of the state is facing several problems. A new approach is very much essential for the governance and conservation of groundwater resources of the state. It involves participation of local people, NGOs, Govt. departments, planners, developers, Panchayath institutions and Scientists and environmentalists. However, research on groundwater use in the socioeconomic context being relatively small, the highly technical knowledge of the aquifer systems is of relatively little use for practical management purposes. Involvement of research institutions, University departments, NGOs, and other stake holders in development and management of ground water resources of the state is very much essential for adopting various water conservation techniques and ensure their adaptability in local conditions. The general attitude of the community in Kerala is that water is nature's gift and therefore be accessed free of charge, used and misused by all for whatever purposes intended. But it's high time to change our attitude towards water. The approach to groundwater quality protection and enhancement varies not only between States but also within them. Within our country, different agencies have differing responsibilities for groundwater quality. This gives an impression to industry and the community that groundwater quality protection in India is generally inconsistent and uncoordinated. It is important for groundwater management that responsibilities are clearly defined, coordinated and accepted by each agency. Furthermore, there is a "duty of care" responsibility on all agencies to act upon the information they receive.

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Geospatial technologies for disaster management - A case study

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ABSTRACT

Effective disaster management system requires solutions and approaches that allow efficient and reliable access to spatial data. Timely access to and sharing of accurate information for the purpose of disaster mitigation, prevention, preparedness, response, and recovery have proven to be a challenge in many recent disasters. The paper illustrates the possible use of geospatial technologies in disaster management. The study area was an active landslide in the Ambwala region (H. P., India) on the banks of River Markanda. The parameters like slope, aspect, drainage and land and land cover were mapped taking inputs from Remote Sensing and Topographical Data. Integrating these specific hazard maps a zonal hazard map of the study area was developed on a GIS platform. This map could be used as a hazard mitigation tool using its capability to predict the probable hazard zones.

1 Introduction

The emerging field of disaster management requires effective solutions and approaches that allow efficient and reliable access to spatial data for the purpose of protecting life and property. Timely access to and sharing of accurate information for the purpose of disaster mitigation, prevention, preparedness, response, and recovery have proven to be a challenge in many recent disasters. This has raised new challenges and opportunities for the geospatial information research community. Land slide as a major natural disaster has been recognized, especially in mountainous terrain. The land slides are mass movements on the surface of the earth predominantly due to gravity which reduces the gradient of hill slopes to stable angles (Price 2009). The gravity triggered mass movements range from rock falls, through a variety of slumps and slides, to debris flows. Although precipitation, earthquakes, and volcanic eruptions are the principal natural drivers of landslides, in many cases landslides result directly from disturbance of hillsides by road construction or other human activity. Landslides contribute to the erosion, transport, and deposition of earth materials.

The major factors cause land slides include geographical, morphological, physical and human activity. The various types of landslides can be differentiated by the kinds of material involved and the mode of movement (Highland 2004). Kumar *et al.* (2010) analysed the landslide hazard potential of Garhwal region (India) using GIS techniques. In this paper the use of geospatial technologies in management of natural disasters is illustrated with a case study of an active landslide zone in Himachal Pradesh (India).

2 Study area

The study area is an active landslide located in the Ambwala Region, Sirmour District, Himachal Pradesh (India) in National Highway 72 on the banks of River Markanda. The latitude and longitude of the site is

Figure 1. Image of the study area.

30°31′26″N and 77°16′32″ E, respectively. The image of the study area is shown in Figure 1. The landslide is situated in the seismic zone 4 and the foliation line of the Shivalik belt also passes through the region. This landslide is also listed under the major landslide hazard zones of India.

3 Data used

3.1 Topographic sheet

The topographic sheet of the aera was digitised and the contour and the drainage map was prepared using GIS techniques.

3.2 Remote sensing data of LISS III sensor March 2008

The satellite data of the area was obtained from the Himachal Pradesh Remote Sensing Centre, Shimla. This data was geo-referenced and a subset of the required area was cut out from the entire area of the Himachal Pradesh. The ground resolution of the LISS III digital image of pixel size of the 23.5m is depicted in Figure 2. This data was used for the generation of land use and land cover map of the required area.

4 Methodology

A scheme of the detailed methodology is presented in Figure 3. For spatial analysis Arc GIS and ERDAS have been used in the study. Different thematic layers corresponding to the causative factors that are responsible for the occurrence of landslides in a region were prepared using RS information and the topographic sheets. The integration of these thematic layers with weights assigned according to their relative importance in a GIS environment leads to the generation of a Zonal hazard map (Kanungo *et al.*, 2006; John *et al.*, 2007; Sarkar & Kanungo, 2004; Gupta *et al.*, 1999).

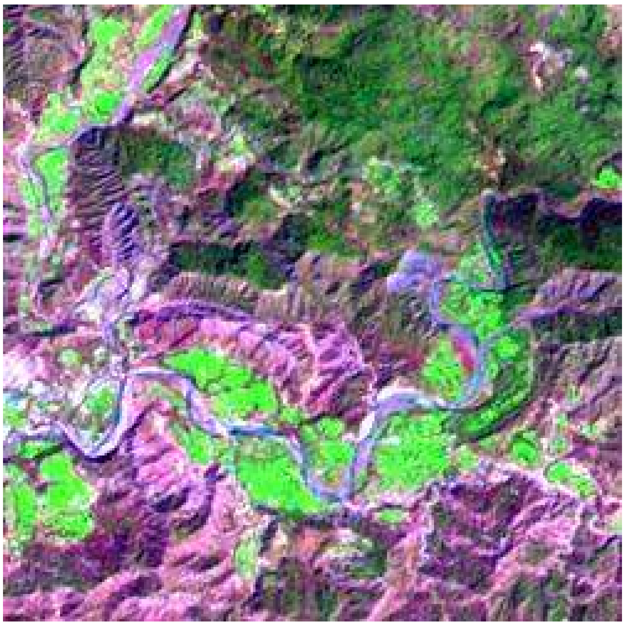

Figure 2. LISS III image of the study area.

5 Results and discussion

5.1 Digital elevation model (DEM)

The DEM was created by scanning and digitising all the contours and converting them into the vector form from the raster layer. Figure 4 depicts the DEM of the study area.

5.2 Slope hazard map

The slope map was generated using GIS tools taking input from DEM map. After assigning weightages to the slopes a slope hazard map of the study area was prepared. Figure 5 shows the slope hazard map.

5.3 Slope aspect map

Figure 6 depicts the slope aspect map of the region. Slope aspect map helps in determining the stability of the landslide.

5.4 Drainage hazard map

Drainage hazard map was generated by assigning wiegtages to the drainage distance. It plays an important role in the determination of the stability of the area. The drainage hazard map is shown Figure 7.

5.5 Land use and land cover map

The ever changing natural details of land use and land cover play an important role in determining the stability of the landslide. IRS LISS III data of March 2008 were used to record dynamic changes in land use and land cover. In this case forested land has the maximum stability and barren lands have minimum stability as the

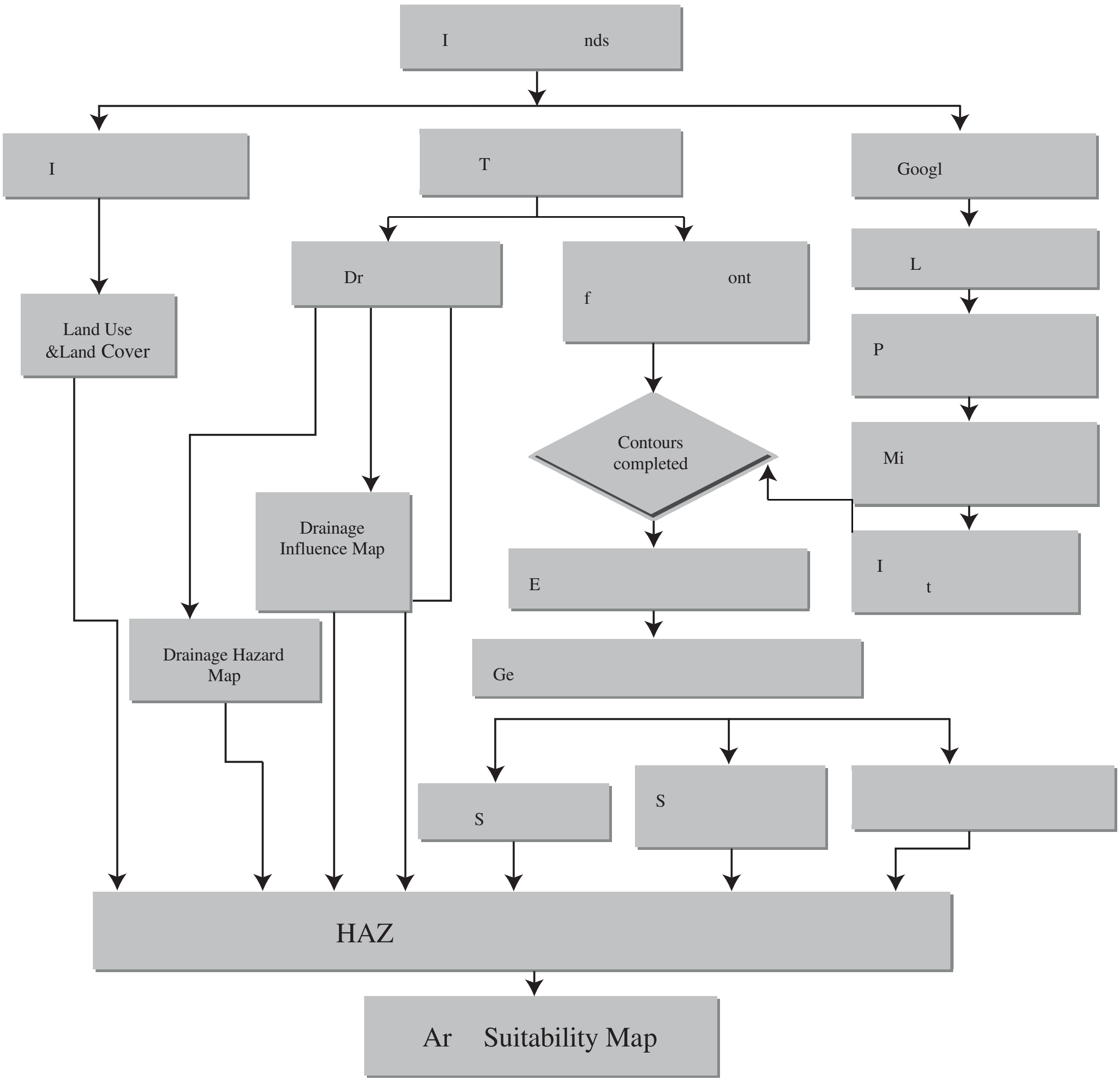

Figure 3. Schematic diagram of the methodology.

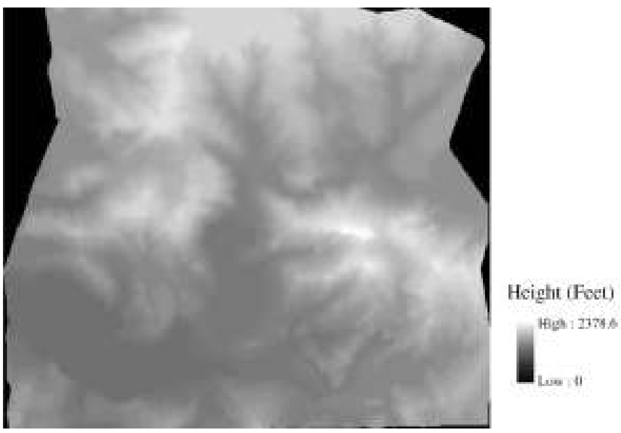

Figure 4. DEM of the Study Area.

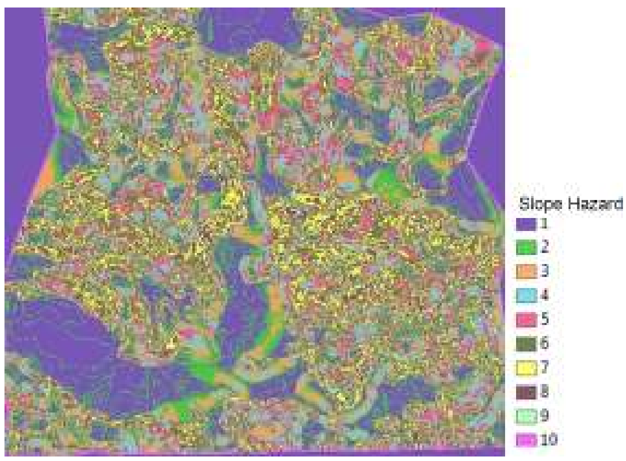

Figure 5. Slope Hazard Map.

forest bind and keep the soil intact while in case of barren lands there is nothing to keep land intact which increased the risk of landslide. The various classifications of the land use and land cover are given in Figure 8.

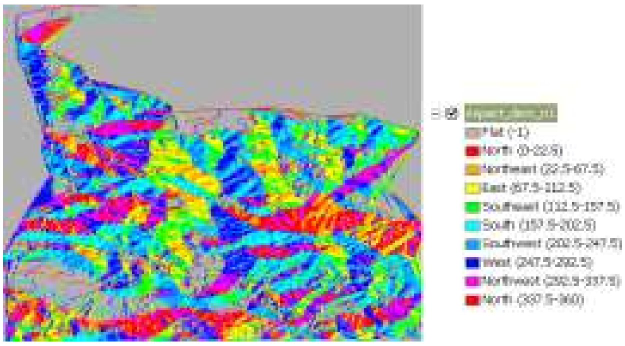

Figure 6. Slope Aspect Map.

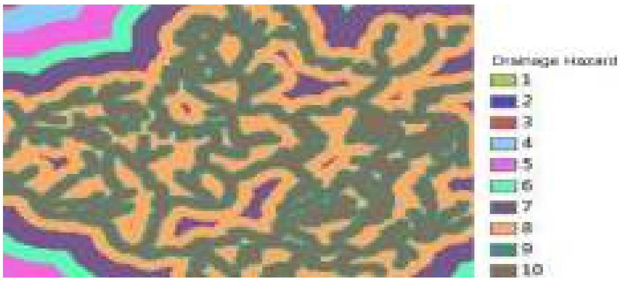

Figure 7. Drainage Hazard Area.

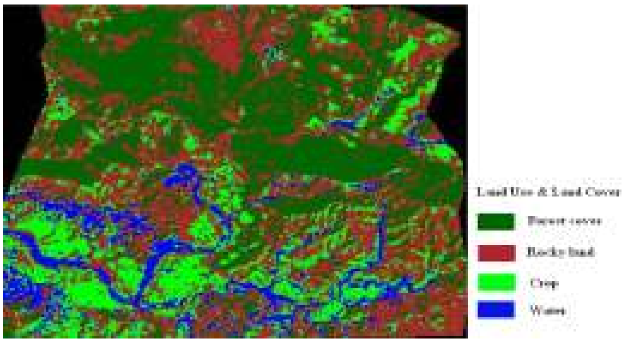

Figure 8. Land Use/Land Cover Map.

5.6 Zonal hazard map

All the above hazard maps using individual parameters have been used to generate a zonal hazard map of the study area. Figure 9 shows the zonal hazard map integrating the input from all the specific hazard maps.

6 Conclusions

The zonal hazard map integrates the effects of all specific parameters which affect the landslide hazard. The zonal hazard map developed in this study could be used as a hazard mitigation tool using its capability to predict the probable hazard zones.

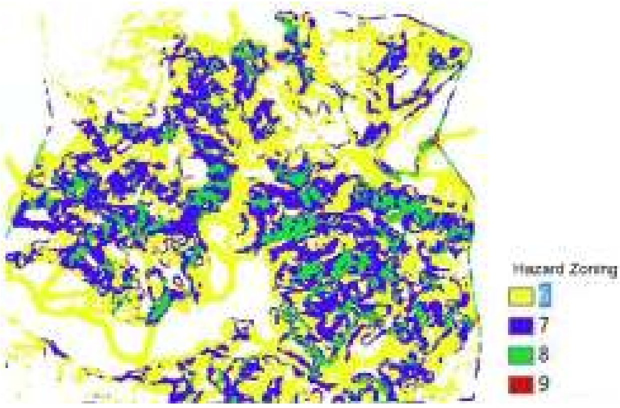

Figure 9. Zonal Hazard Map.

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Pre-tsunami water quality of alappad coast: A critical evaluation

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Piper diagrams

ABSTRACT

Last tsunami event on Indian coast (26 December 2004 Indian Ocean Tsunami) initiated a realm research activities spanning from geophysical aspects of tsunami to ecological damage assessment and mitigation measures. The coastal hazard had been new to many researchers to part take in the so called rapid response studies to gem out early as much as valuable findings and inferences. Dire need of primary data to correlate to the post tsunami condition of a specific region to that actually exited in time before the ocean hazard had been the most difficult part of the many of the so called successful field missions. Everywhere on coastal belt the pristine ground water quality after tsunami has been severely deteriorated, but how far? The answer rests on the finger print of the ground water quality measured and tabled in a readily understandable primary data form gathered from the earlier studies. Hill-Piper Trilinear plots indicate that slight contamination by sea water has been prevalent; may be the geographical features of the place- a narrow barrier islet infringed by Laccadive Sea and an arm Ashtamudy lake called TS canal.

1 Introduction

Post-tsunami study of ground water quality along the coastal areas of India after 26 December 2004 tsunami had a serious thought of research initiated by many researchers (Achari *et al.*, 2006). It has been very essential to have baseline data to identify zones of rapid ecological damage prone to such future ocean disasters. Ground water quality deterioration, the extent of dilution and replenishment of water in the post tsunami situation are the basic motivation of many of such studies. The need of a refined water quality index profile specific to coastal region lacked in reality enough to formulate the baseline situation prior to the tsunami event. In Kerala data in crude form is available with many monitoring agencies not statistically put into evaluation to refine out the inference on a time scale. In this circumstance we make an attempt to come up with a set of reliable inferences to the true behavior of the ground water in a pretsunamic period in full conformity with the set of data already available (Achari, 2006, 2007 & 2009).

The main objective of this paper is to simulate a graphical description of the ground water quality of this one of the severely devastated region of Indian coast by tsunami as a finger print control as a reference standard to make evaluations and judgments in the post tsunami situations and similar coastal disasters of the future.

2 Methodology

The pre tsunami water qualities of the region had been obtained from the reports (Achari, 2006) and are available with many government agencies as they have permanent monitoring stations (Table 1). But a true judgment could be strictly possible ones the data is subjected to rigorous statistical/ mathematical permutations: This was done putting the available data with the so called '***t***' test and graphical simulations. Here the data had been mainly interpreted based on their relative ionic ratios and Hill-Piper-Trilinear plot behavior (Piper, 1953).

Table 1. Base line water quality data of Alappad coast. Source: Central Ground Water Board (year 2001), Government of India, Thiruvananthapuram.

No.*	pH	EC *mmho/cm*	TH mg $CaCO_3$/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	Cl mg/l	F mg/l
1.	6.8	0.353	44	13	2.9	42	8.1	0	9.8	0.7	58	0.08
2.	7.5	0.356	66	13	8.3	41	0.6	0	34	34	64	0.1
3.	8.2	0.466	152	52	5.4	27	14	–	127	47	60	0.07
4.	8.0	0.280	56	14	4.9	11	25	2.6	–	20	31	0.09
5.	7.5	0.307	22	4.8	2.4	46	2.5	0	0	0.5	70	0.08
$\bar{x} \pm \sigma$	7.5 ± 0.5	0.352 ± 0.071	68 ± 50	19 ± 19	4.8 ± 2.3	33 ± 14	10.0 ± 9.9	0.5 ± 1.2	34.2 ± 53.7	20.4 ± 20.5	57 ± 15	0.08 ± 0.01

3 Results and discussion

Chemical trends or behavior of ground water is commonly interpreted based on graphical simulations or plots made individually either in the form of x-y plot or triangular diagrams. In the conventional two dimensional x-y plots only individual analysis are marked and trends are interpreted as an expression of the solution behavior. Each graph of the triliniar is a singular representation of ionic character and fate under a set of specific conditions. To study ground water chemistry, only major components of the water are generally plotted. Amongst them concentration of $Na(+K), Ca, Mg, Cl, SO_4^{2-}$, and $HCO_3^-(CO_3^{2-})$ are generally represented. In real trends plotting, individual data are used based on unique analysis and shapes are interpreted. In chemical trend plots all analytical observations are presented as points in one diagram.

It is a graphical method and a very complex way of presenting data in water quality studies (Hounslow, 1995). Only three variables can be plotted in a triangular graph. In triliniar plots apices of the diagram shows 100% concentration of a component and the opposite side 0%. Many occasions the graphs contains the variation of three components in a single graph: A constitutes the apex (100%) and BC represents 0%. Similarly if B is 100%, AC is 0%.

Similarly, if C is apex [100%] then side AB is 0% of the component. Each line if drawn parallel to the base opposite to the apex of the component represents the different percentages of each component. The point of intersection of two lines represents two of the three components of a sample measured; is the point represents that analysis. The third component can be evaluated from the same graph. The point generally appears on one side of a triangle that represents a two component mixture of the constituents represented at each end of the line (Hounslow, 1995). Similarly, if C is apex [100%] then side AB is 0% of the component. Each line if drawn parallel to the base opposite to the apex of the component represents the different percentages of each component. The point of intersection of two lines represents two of the three components of a sample measured; is the point represents that analysis. The third component can be evaluated from the same graph. The point generally appears on one side of a triangle that represents a two component mixture of the constituents represented at each end of the line (Hounslow, 1995).

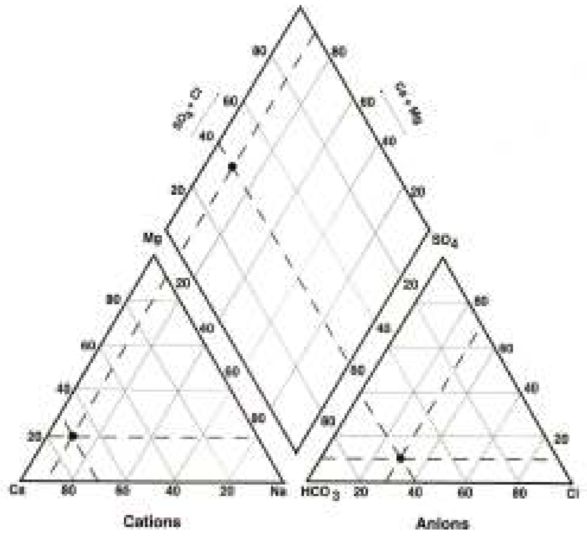

Figure 1. Apices of Hill - Piper - Triliniar plot.

The limitations on plotting two variables in a single triangular graph can be overcome by plotting cations and anions separately on adjacent triangles. They can be favorably arranged to make the interpretation properly simple (Hounslow, 1995). Despite the easiness favorably making the inferences very elusive, the graph plots only ratios making the dilution factor exclusive. Common triangular (trilinear) plots used and followed to interpret water quality data are Piper diagrams and Durov graphs.

3.1 Significance of Piper diagrams

Piper diagrams (Piper 1944) are a construct of two triangles that are supposed to share a common base line and each side are separated by an angular distance of 60° apart. The two are interlocked by a diamond cut design shaped graph to contain repotted values of the data (ionic concentrations) as circles. The area of this graph is proportional to TDS. The data position on Piper diagrams are really finger print information to reach tentative conclusions; origin of the water and its character in particular. Basically, Piper diagrams provide very

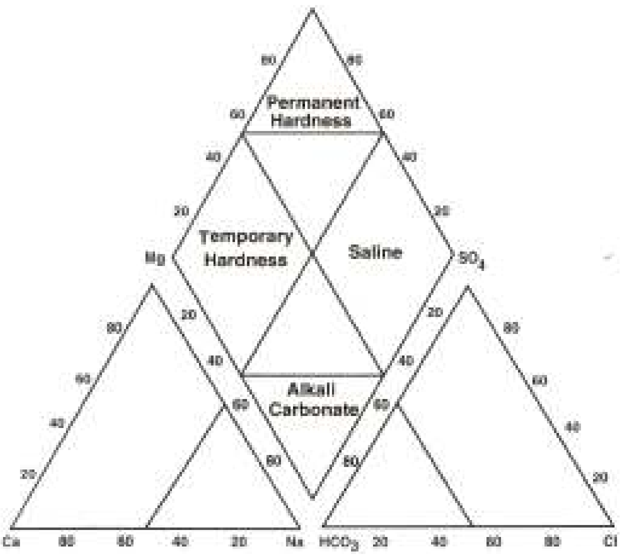

Figure 2. Water type classification as per diamond portion of Piper diagram.

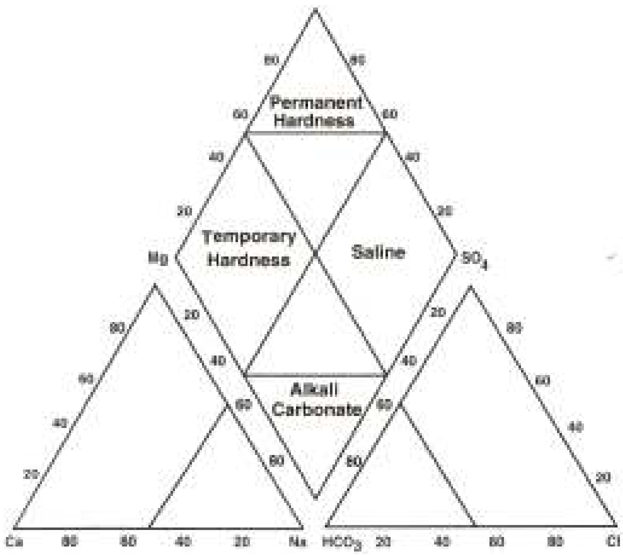

Figure 3. Hill - Piper - Trilinear plot of station1 as per the Table 1 (a dug well near to the shore).

valuable knowledge on the water type, precipitation or solution behavior, mixing character and ion exchange phenomena.

Water Types: The diamond shape of the Piper diagram and its four corners are indicative of nature of the water type as shown in the model graph (Figure 2).

According to Piper water belongs to mainly four different water types based on their positions near the corners of the diamond. *Permanent hardness:* Water with plot data at top of the diamond, i.e. high in both [Ca+Mg] and [$Cl+SO_4^{2-}$] ions indicates character of permanent hardness. *Temporary hardness:* Water with plot values at left corners of the diamond has character of *temporary hardness*. Ions [Ca+Mg] and HCO_3^-] are prominent. *Hardness due to soft-ions:* Water with plot data at lower corner of the diamond has hardness due to soft ions due to alkali carbonates [Na+K] and [$HCO_3^- + CO_3^{2-}$] ions. *Hardness due to saline ions:* water with plot data at right corners are classified as *saline*: [$Na^+ + K^+$] and [$Cl^- + SO_4^{2-}$] ions are prominent.

The basic hydrochemical phenomena that govern the ultimate behavior of water are judged based upon the form and nature of the Piper charts. Expression of hardness type and nature will provide us indication of the exact phenomena, either due to Precipitation, Mixing and Ion Exchange.

3.2 Sodium - chloride ratio

The brackish water of ground water may be due to Cl ions or metals combined directly with chloride. Though hold level of chloride in drinking water is 250–500 mg/L, and even a high level of 1500 mg/L is not harmful for healthy consumes. The chloride content on taking as a ratio with sum of anions give an indication of source of the water; whether seawater or brine or evaporate, rain water or rock weathering. This inertia is also decided by TD value (Hounslow, 1995)

$$\frac{\text{Cl}}{\text{Sum anions}} = >0.8 \text{ TDS } > 500 \text{ Seawater or brine or evaporate}$$
$$= >0.8\text{TDS} < 100 \text{ Rain water}$$
$$<0.8 \text{ Rock weathering}$$

In water contaminated with sources other than halite Na^+ content will be higher than sum of Na^+ and Cl. Here too TDS remains as the balancing factor (Hounslow, 1995)

$$\frac{\text{Na}^+}{\text{Na}^+ + \text{Cl}^+} = >0.5 \text{ Sodium source other than halite-albite, ion exchange.}$$
$$= 0 \text{ (Halite solution)}$$
$$= <0.5\text{TDS} > 500 \text{ Reverse softening seawater}$$
$$= <0.5\text{TDS} < 50 \text{ rain water.}$$

3.3 Pre-tsunami data analyses

In the pre tsunami situation the $\bar{x}(\text{Na}^+/\text{Na}^+\text{Cl})$ for the known five stations consisting of so called control dug well (station 1), common dug wells (2,3 &5) and a representative deep ground water source (bore well depth 75.0m) has a ratio of 0.27. This indicates the water is of rainwater origin. The deep ground water has the lowest ratio of 0.19 is having entirely a different character than the dug well source water. Since the ration ranges between 0.19–0.32 band, and it do not cross the limit of 0.5 either we could confirm that the ground water has an inherent existence originated from rain water over a period time. To confirm whether it is replenished by reverse softening or slightly contaminated by the seawater more data treatment is necessitated.

4 Conclusions

Quality of the ground water in this small spec of land is of highest grade on evaluation based on the above said protocol on analyzing the water quality parameters with based on the data available in 2001 as a case of pretsunami situation. This may be the one of the reason the area is thickly populated though the geographically not conducive for safe settling other than fishing.

Acknowledgement

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Drought hazard mapping in chinnar wildlife sanctuary using GIS and remote sensing

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ABSTRACT

Remote sensing and geographic information system have significantly aided identification of drought vulnerable areas in the recent past. Drought is one of the natural disasters having an impact on both the economy and the society, with its long-standing problems. Drought by nature is a result of inter-related parameters. The study is based on the concept that the severity of the drought is a function of rainfall, hydrological and physical aspects of the landscape. In the present study a Geographic Information Systems (GIS) and remote sensing based tool for drought vulnerability assessment at a micro level has been developed. The present study identified drought prone areas of the Chinnar wildlife sanctuary in the Idukki district in Kerala. The Chinnar wildlife sanctuary falls in the rain shadow region of Kerala. The final map shows different zones of drought vulnerability ranging from low, medium, high and very high.

1 Introduction

Drought is one the climatic as well as natural disasters common all over the world. Droughts have disastrous impact on the economy and can affect the largest segment of the society, which may last for months and in some cases several years (SAARC, 2010). Drought is more often like a cancer on the land, mute but sure assaulter that seems to have no marked beginning or ending; a malaise slowly engulfing the community and often leaves just as gradually (Sergio, 2007; Vaughan, 1985). Drought may be categorized as continuing disasters and as the time passes, the situation may further deteriorate. The continuing disasters include prolonged droughts and crop failure (Lawrence, 2006). These continuing disasters or drought affects a very large area. The droughts may compound longstanding problems of deforestation, encroaching desertification, soil erosion, forced migration, malnutrition, epidemics and loss of life over vast stretches of land for many years. Agriculture may suffer severe set back and large groups of affected population may have to migrate (Valdiya, 2006). In turn, it may cause pressure on urban centers, creating new demands and infrastructure. The meteorological causes of drought are usually associated with slow, prevailing, subsidizing motions of air masses from continental source regions (Sankar, 2006). These descending are of order 600 or 900 ft/day resulting in compressional warming of the air and therefore reduction in the relative humidity, inhibiting the cloud formation. Remote sensing techniques are widely used for the drought monitoring and management (Elvidge, 1997).

2 Study area

The study area is located between latitude 10°15′-10°21′ N and Longitude 77°5′-77°16′ E. The study area is Chinnar wildlife sanctuary which is located in the rain shadow region of Western Ghats of Kerala, India., and represents a large number of plants and animals unique to the thorny vegetation. The location map of the area is shown in the map.1. Apart from the dry thorn forests, due to the significant variation in altitude and rainfall, it has a wide array of habitat types like deciduous forests,

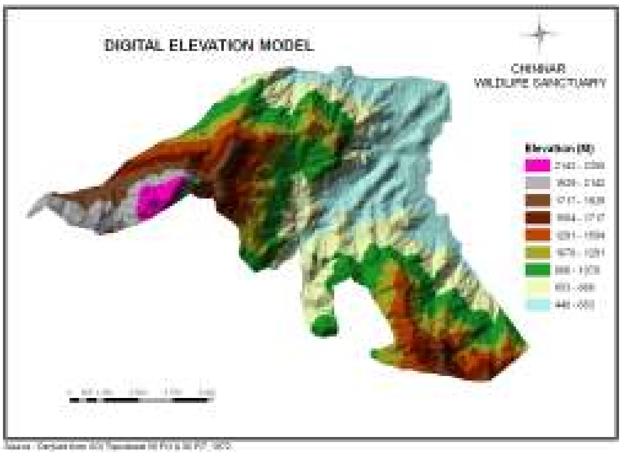

Figure 1. The location map of the area.

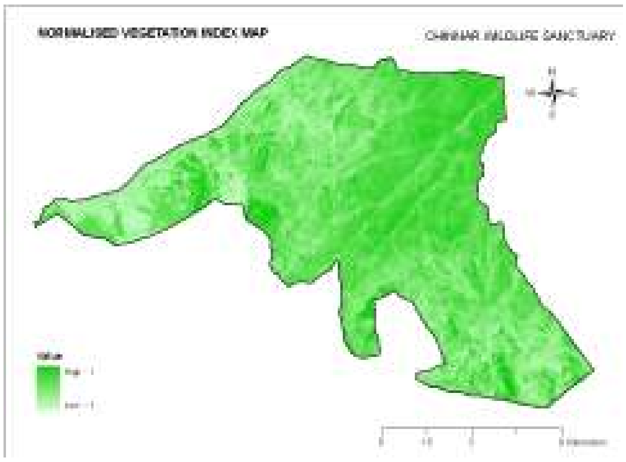

Figure 3. NDVI map.

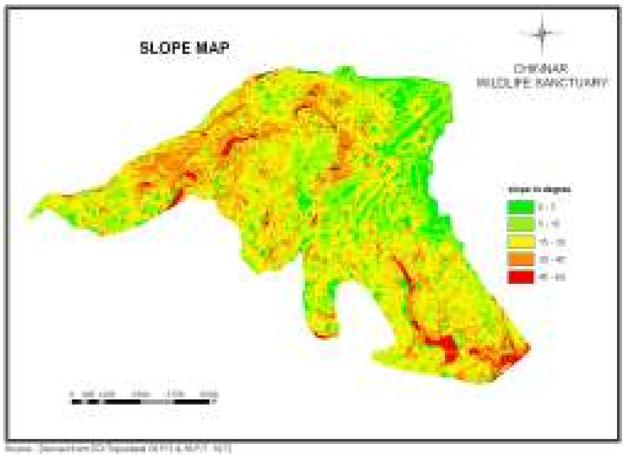

Figure 2. Slope map.

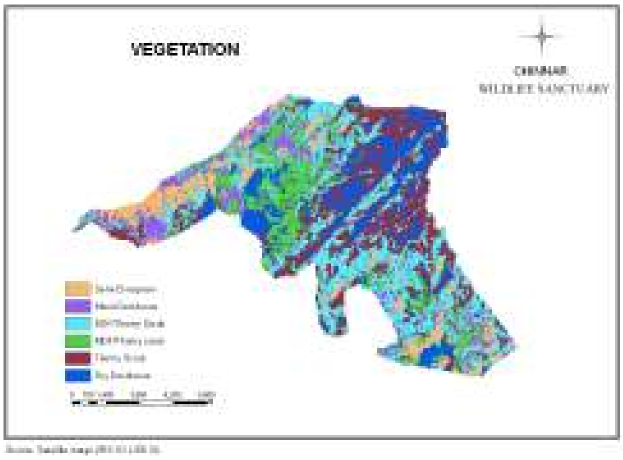

Figure 4. Vegetation map.

dry thorny forest, riparian types, sholas and grasslands that are interspersed with plains, hillocks, rocks and cliffs which provide microhabitats for varied forms of life. The area is situated in the rain shadow region of the Western Ghats, getting rains mostly during the north-east monsoons (October-December). The average annual rainfall is 500mm.The plains are generally hot.

The area is situated in the rain shadow region and hence the area experiences prolonged hot/dry season and much less rainy days. The Chinnar plains are generally hot, but the higher altitudes are cool. The solar radiation is high, mainly because of less cloud cover.

3 Methododlogy

The data sources for the present study are the Survey of India toposheets, soil map, field data and Remote Sensing Data. The Survey of India Toposheets (1:50000) is used for the delineation of basic features of the study area. The IRS P6 LISS3 2006 Image was used to generate landuse (Figure 4) pattern of the study area. From this landuse map Normalised Difference Vegetation Index was calculated (NDVI) by using image processing software. NDVI map is shown in the Figure 3. The drainage network of the study area is derived from the topographic sheets. Moreover the Drainage density is also derived from streams using spatial analyst of ARC GIS 9.3. Elevation (Figure 1) and slope (Figure 2) have a direct relation between the drought. Increased slope and elevation will positively contributed to the drought. The preparation of the drought vulnerable maps assesses the drought potential of any area. In the present study, drought vulnerable areas were generated by giving weightage to various parameters that influences the drought. The method for the drought vulnerable assessment used in this study is weightage factor model. The weightings assigned to each terrain parameter to reflect its importance in the occurrence of drought together with the rating for the individual classes, which denotes the degree of hazard represent.

Temperature and rainfall were collected from IMD (Indian Meteorological Department) and where analyzed using geo statistical analyst in GIS. The interpolation method used for the analysis is Kriging : 'An interpolation technique for obtaining statistically unbiased estimates of spatial variation of known points such as surface elevations or yield measurements utilizing a set of control points'. The spatial variation is quantified by the semi-variogram. The spatial distribution of rainfall and temperature (Figure 5) are used for the assessment of drought. Increased temperature and decreased amount of rainfall favors the drought. Drought influencing factors such as NDVI, landuse, soil drainage, soil slope, drainage density, temperature, rainfall, are

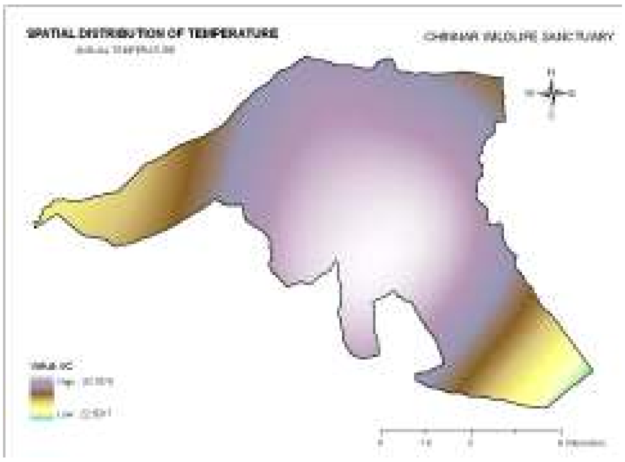

Figure 5. Temperature map.

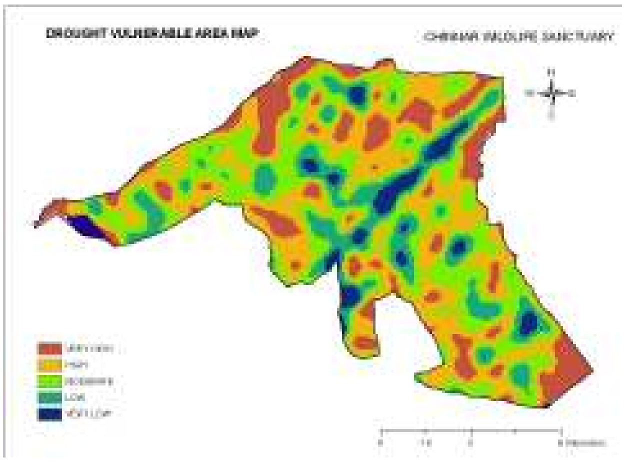

Figure 6. Drought vulnerability map.

ranked and weighted according to their assumed or expected importance in causing drought. This is normally based knowledge available to experts on various causes of drought in the area of investigation. For application of the WeF model, numerical values were assigned to each of the each classes of each factor. A numerical weight is attributed for each instability factor and then an overall score (drought index) is determined by the use of the following multiplicative model. Overall drought index (DI) = a1∗F1 + a2∗F2 + a3∗F3 + a4∗F4 + a5∗F5.Where a1, a2. . . a5 are the numerical weights and F1, F2. . . F5 are the factors as thematic layers that were taken into account to the drought mapping. Drought vulnerable map is shown in the Figure 6.

4 Results and discussion

The drought prone map shows that the study area is divided into four zones based on the severity of drought; these are very high, high, moderate and low. In the regions of low drought severity drainage density is very high and the land use pattern is mainly forest. In low drought severity region the temperature is low and rainfall is high compared to other region this is because of the elevation of that region. In low drought prone area the vegetation index is high that means it near to one. The high vegetation index value shows that the vegetation vigor of that are is high. And this provides moisture to the environment. Soil drainage of the low drought area is imperfectly drained compared to others. In very high drought vulnerable area the vegetation index is very low, soil is well drained, temperature is high, the availability of rainfall is low, land use is mainly agriculture and soil slope is moderately steep.

5 Conclusion

India being a tropical country with hot and humid climates and high temperature conditions delay in the monsoons as well as high evaporation rate of the surface water bodies is making some of the regions into drought areas. As the drought is dynamic in nature, which builds over a time, timely and reliable information is essential for effective drought monitoring and management. Satellite remote sensing provides multispectral, multi spatial and multi temporal data useful for drought monitoring, assessment and management. The present study is a comprehensive evaluation and integrated analysis of drought, which has been carried out by using satellite based remote sensing and GIS techniques. Adverse climatic conditions may further convert these high drought prone areas to severe drought areas. Some action plans comprising of drought proofing works, employment generation programmes and social security programs were discussed for managing the drought prone areas.

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Landslide prediction mapping using geoinformation techniques

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ABSTRACT

Landslides occur in a large variety of forms depending on the type and speed of movements, the material involved and the triggering mechanism. The study was undertaken in the Idukki district of Kerala characterized by highly undulating terrain with steep slopes. A spatial database was constructed from topographic maps, geology and land cover. Land cover was classified from IRS LISS III satellite imagery. Frequency ratio models were done for the preparation of landslide hazard zonation mapping and the field data compared statistically. The prepared landslide zonation map was overlaid by field landslide data and combined together to prepare landslide prediction map. The landslide susceptibility map classifies the area into four classes of landslide susceptible zones i.e., very high, high, moderate and low. Based on the landslide zonation map landslide prediction map was prepared. The accuracy of landslide prediction map was verified by field investigation using GPS.

1 Introduction

Natural disasters such as landslides, earthquakes, flood, drought, cyclone, volcanic eruptions, environmental degradation etc are of global phenomenon. Most of the countries are experiencing either one or more disasters at regular interval. International Decade for Natural Disaster Reduction, of the UN resolution (1989) aims at minimizing the loss of life, damage to property and description of economic and social activities through concerted actions. Landslide is a common and major natural hazard, often triggered by rainfall. The term landslide is used to denote the movement of mass rock, debris or earth down a slope (Zezere, 2004). Many other scientists consider landslides as 'a sudden, short-lived geomorphic events that involved the rapid-to-slow descent of soil or rock in slopping terrain'. Mass movements occur whenever the downward pull of gravity overcomes resisting forces. Downward pull is related to material mass and slope gradient .When this pull or shearing stress exceeds frictional resistance movement occurs. Generally steeper slopes are more prone to failure (Lee, 2006).

Landslide events are associated with various physical factors and therefore almost all methods of landslide susceptibility mapping focus on: (a) the determination of the physical factors which are directly or indirectly correlated with slope instability (instability factors); (b) the selection of the rating-weighting system of all instability factors and of the classes of each one of them; (c) the overall estimation of the relative role of causative factors in producing landslides; and d) the final susceptibility zoning by classifying the land surface according to different hazard degrees (Kumungo, 1995; Rao, 1994).

The present study tries to identify different landslide prone area by using most modern technologies like GIS and remote sensing. The spatial data in GIS data predominantly generated from remote sensing through the import of images, also through the generation of topographic maps. In the present study a grid based Geographic Information System (GIS) is used to analyse the factors responsible for landslide. Geographical Information Systems (GIS) and Remote Sensing have become

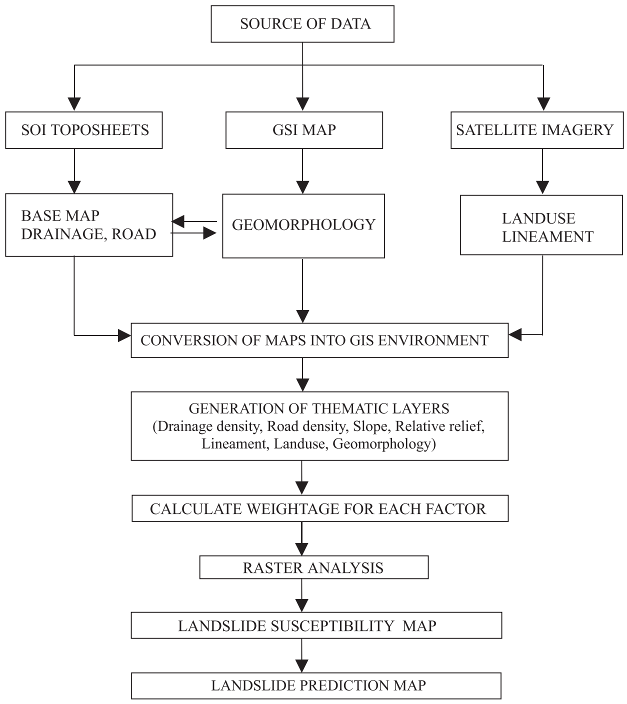

Figure 1. Location map of study area.

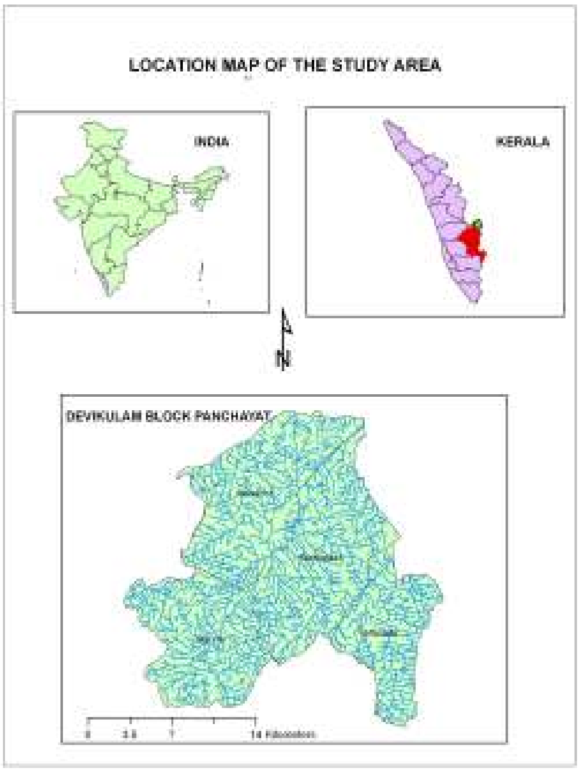

Figure 2. Slope map.

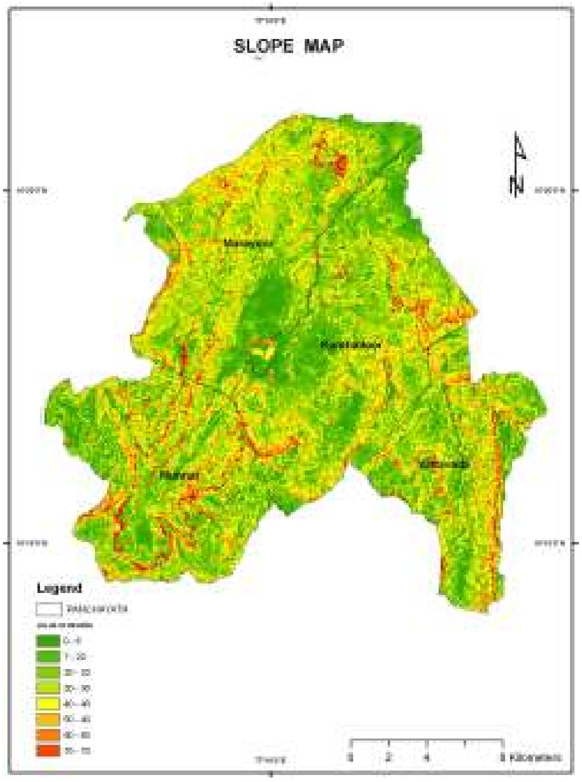

Figure 3. DEM.

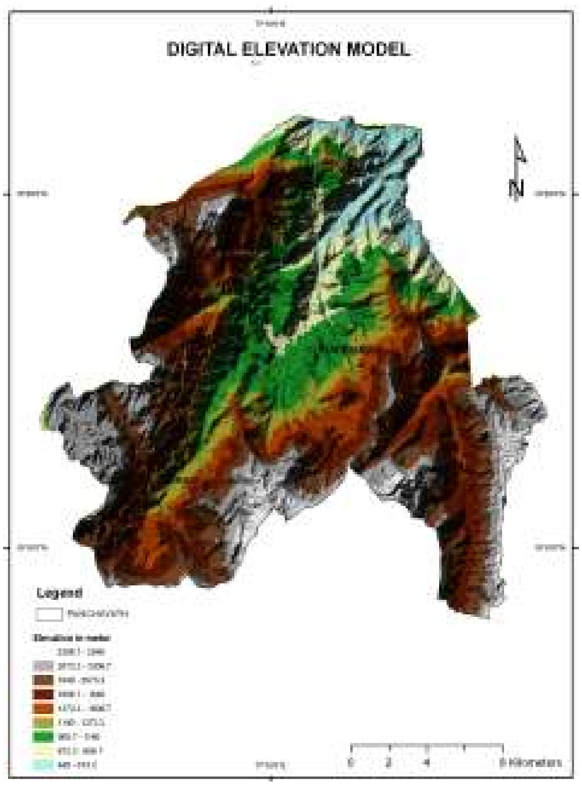

Figure 4. Landuse.

integral tools for the evaluation of natural hazard phenomena (Nagarajan *et al.*, 1998; Liu *et al.*, 2004). Moreover, GIS is an excellent and useful tool for the spatial analysis of a multi-dimensional phenomenon such as landslides and for the landslide susceptibility mapping (Vaughan *et al.*, 1985; Lan *et al.*, 2004).

2 Materials and methods

The data sources for the present study are the Survey of India toposheets, Geological map prepared by GSI (1:25000), soil map, field data and Remote Sens-

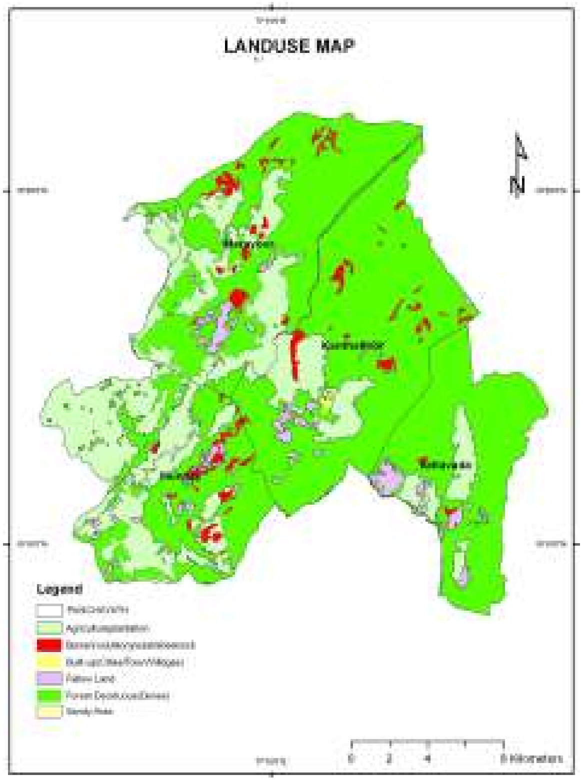

Figure 5. Geomorphology.

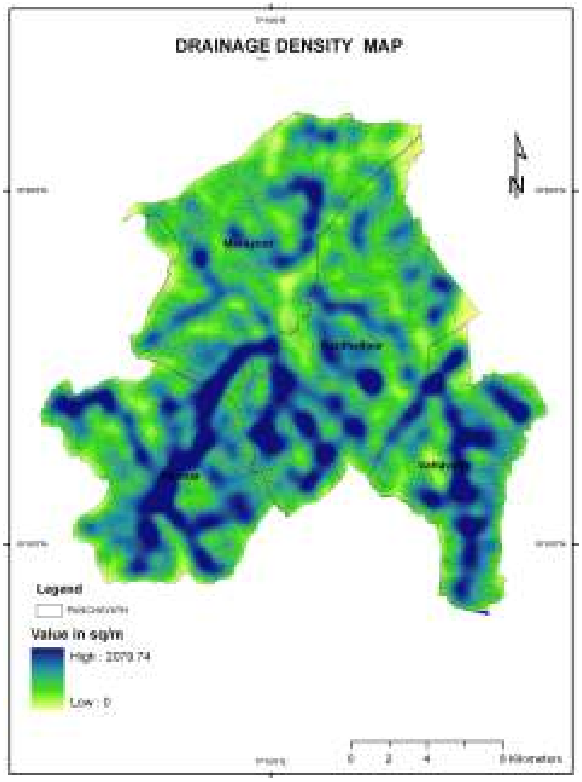

Figure 7. Road density.

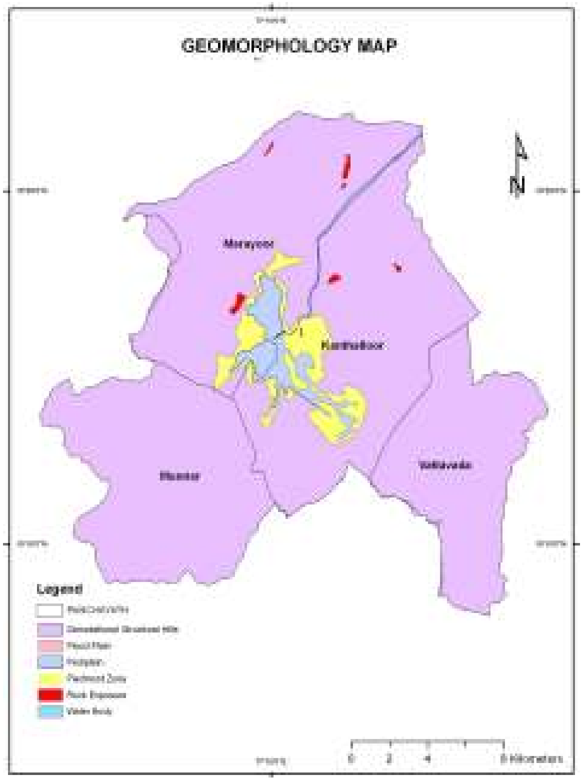

Figure 6. Drainage.

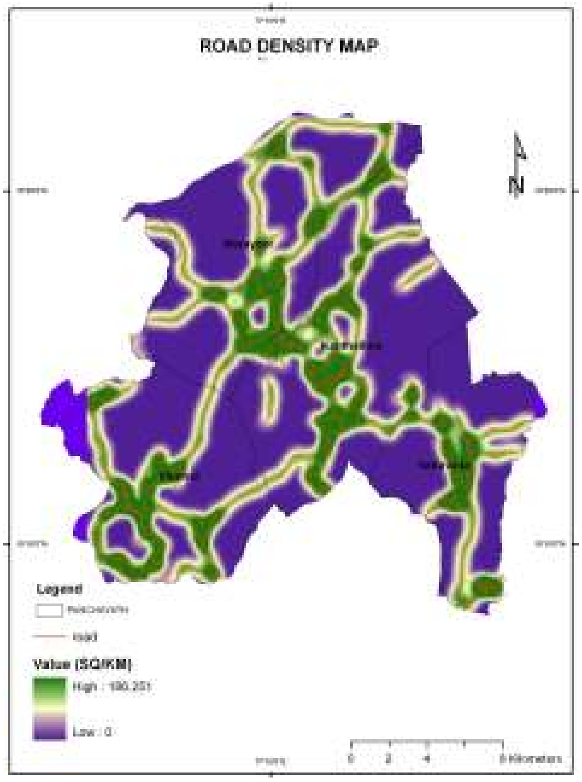

Figure 8. Rock type.

ing Data. The Survey of India Toposheets (1:50000) provided the geomorphology (Figure 5), location map (Figure 1), elevation (Figure 3) and road density (Figure 7) of the area. The IRS P6 LISS-III 2007 Image was used to generate landuse (Figure 4) pattern of the study area. The drainage network of the study area is derived from the topographic sheets. Moreover the Drainage density (Figure 6) is also derived from streams using spatial analyst of ARC GIS 9.3. The total study area is then classified into three drainage density zones, low

Figure 9. Landslide prediction map.

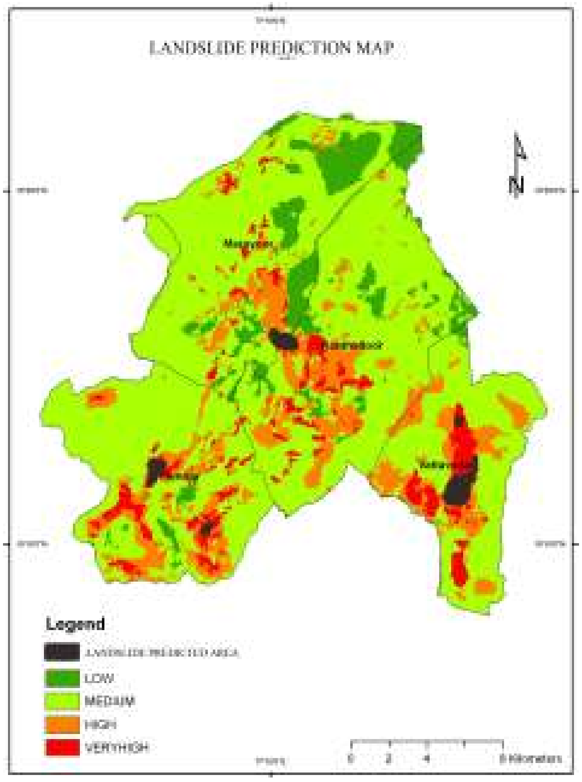

Figure 10. Methodology flow Chart of Data Preparation and analysis.

(0–10000), medium (10001–20000) and high (20001–40000). Road density is also calculated using the same method. Rainfall data were collected from the near by meteorological station (monthly data) and interpolated by using geostatistical analyst.

Geomorphology is also derived from the toposheets. The study area is classified into six geomorphic classes. Landuse/landcover was prepared using IRS P6 LISS-III 2007 image by the visual interpretation. It is classified into five classes. Lineament density is also calculated using spatial analyst and is classified in to three, low (0–6000), medium (6001–9000), high (9001–12000). Soil slope and soil texture was derived from soil map and field investigations. The slope (Figure 2) and relative relief of the study area is derived from Digital Elevation Model (Figure 3) (DEM) prepared from the contours and spot heights in the toposheet. The slope of the study area ranges from 0–90 degrees. They are classified into six classes. The relative relief of the area is derived using the neighborhood statistics of the spatial analyst and is classified into five classes. Methodology flow Chart of Data Preparation and analysis shown in Figure 10.

The preparation of the landslide susceptibility maps assesses the landslide potential of any area. In the present study, they are generated by giving weightage to various parameters that influences the landslide. The method for the landslide assessment used in this study is weightage factor model. The weightings assigned to each terrain parameter to reflect its importance in the occurrence of landsliding together with the rating for the individual classes, which denotes the degree of hazard represent.

Landslide influencing factors such as slope, landuse, geomorphology, lineament, relative relief, drainage density, rainfall are ranked and weighted according to their assumed or expected importance in causing mass movements. For application of the WeF model, numerical values were assigned to each of the susceptibility classes of each factor. A numerical weight is attributed for each instability factor and then an overall score (susceptibility index) is determined by the use of the following multiplicative model. Overall landslide susceptibility index (LSI) = a1 * F1 + a2 * F2 + a3 * F3 + a4 * F4 + a5 * F5. Where a1, a2...a5 are the numerical weights and F1, F2...F5 are the instability factors as thematic layers that were taken into account to the landslide susceptibility mapping. Landslide susceptibility map was shown in the Figure 9. By using the previous landslide location, we overlay the landslide susceptibility map and field data prepare landslide prediction map.

3 Result and discussion

The landslides related factors chosen for the present study are Lithology, Landuse, Slope, Relative Relief, Curvature, Drainage Density, Road density, Distance from Road and Distance from Streams. Rainfall is the main triggering factor for the occurrence of landslides in this area and has a significance role in the landslide prediction. These each factors has their own role in triggering the landslides of their region. Again these factors are classified into feature classes to find out which class contributes more to landslides. Frequency ratio is used to represent the distinction quantitatively. The greater the ratio above unity, the stronger the relationship between landslide location and the given factor's attribute. To calculate the frequency ratio, a table was constructed for each landslide related factor. Then the ratio of landslide occurrence and non occurrence was calculated. Finally the frequency ratio for each range or type of factor was calculated by dividing landslide occurrence ratio by the area ratio.

As a result it is found out that the varied land use indicates that plantation is more prone to landslides with a frequency ratio of 1.709. The relationship between slopes and landslides show that slopes between 20° to 30° range has the highest probability of landslide occurrence with a frequency ratio 2.36. The aspect simply shows that the North-West and north facing slopes has the highest probability with greater frequency ratio of 1.66 and 1.58 respectively. The region with convex curvature is relatively more probable than with concave curvature. The relative relief indicates that region with relative relief ranging from 50–75 has the highest probability with frequency ratio of 2.23. The high drainage density regions show least probability of landslide while the low drainage density regions show high probability of landslides. Moreover the landslide probability is higher in the low drainage frequency areas. The distance from road indicates that less than 250 m from the road is more probable to landslide. The distance from streams indicates that higher the distance from the streams lower the probability of landslides.

Finally Landslide prediction Map was prepared. On the basis of this the study area was divided into four zones. They are low, medium, high and very high. The result is verified using Success Rate Curve which indicates that 20% of the area covered 55% of landslides. This validates the applicability of the proposed method. Hence it can be concluded that the computation of landslide susceptibility zonation is of critical importance to decision making for civil protection and planning. Moreover the use of GIS and Remote Sensing adds to its advantage of efficiency and accuracy.

4 Conclusion

Landslide cause enormous loss of life and property every year in mountainous area, in such regions landslide susceptibility zonation is necessary with a view to delineate the disaster prone areas. Landslide susceptibility analysis is an analysis undergone to predict the landslide prone areas based on the previous landslide locations. Landslide susceptibility should be primary consideration in landuse planning. The international community has acknowledged the significance of geological hazards in landuse planning by naming 1990–2000 the decade for natural hazard reduction (Pachauri *et al.*, 1998).The landslide susceptibility map immediately conveys areas of very high and high susceptibility, which warrant special consideration by landuse planners. These areas that have not been developed should be restricted to compatible landuses such as natural preserves, parks and hiking trails. These non invasive landuses do not exasperate landslide problems by loading slopes, removing vegetation, or undercutting slopes, any combination of which could catalyze mass wasting. Moreover, these landuses do not involve expensive buildings and related infrastructure, there by reducing financial losses in the event of a landslide.

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Climate smart adaptive social protection implementation framework: Background and concept exposition

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ABSTRACT

Background: Addressing the challenges posed by climate change, financial volatility, social and political marginalization lie at the heart of three most prominent social policy approaches namely—disaster risk reduction, climate change adaptation and social protection. Fundamental to these approaches are two constructs — reducing vulnerability and building resilience across four dimensions — social, economic, environmental, and political with spatial, temporal and sectoral connotations. Given these multi dimensional connotations, therefore, it becomes imperative to consider overlaying the common constructs of each of the approaches into a climate smart implementation framework to achieve both efficiency and effectiveness in reducing vulnerability and building resilience. Aim: To present a climate smart adaptive social protection implementation framework concept that proposes to devise and deliver climate smart adaptive social protection programmes for reducing the vulnerability and building the resilience of individuals/communities/societies. Method: The concept is arrived at after analyzing the constructs of natural disaster and climate risk hotspot programmes, vulnerability index programmes, adaptive social protection (ASP), climate change adaptation, disaster risk reduction, climate smart disaster risk management approaches in vogue and distilling their essence into a closed loop implementation framework comprising four pillars of implementation namely — multi stakeholder platform, vulnerability research, advocacy and a programme management office. Conclusion: While the concept is promising, the challenges of implementing it remain. And these lie in the tools for GIS based hot spotting, consistent vulnerability indices construction and integration along social, economic, environmental and political dimensions, multi disciplinary capacity building, ASP programme options generation, funding, exemplary political will and execution.

1 Introduction

Risk is a function of hazard, vulnerability, development and exposure. The strategies to reduce risk then clearly lie in reducing hazards, vulnerability, minimizing exposure and undertaking development in a way that overall resilience gets built over (time and space). Hazards could be both natural and man-induced such as climate change. While there is substantial body of scientific knowledge related to the understanding of natural hazards —such as droughts, floods, earth quakes, cyclones, volcanoes and land slides, the knowledge base related to hazards from climate change is continuously evolving and has with it degrees of uncertainty associated. This knowledge, related to, temperature, precipitation, wind patterns, heat, cold, wet and dry periods, their frequency and intensity is evidently quite distinct from the natural hazard knowledge that is in vogue. Hence, it becomes necessary to distinguish between natural and climate hazards, map them separately to better address the risks emanating from their frequency and intensity.

Next, vulnerability needs to be mapped in all its aspects—economic, social, environmental and political to arrive at optimal solutions for reducing it. In a similar vein development pathways need to take into consideration among other things—evolving evidence on climate and natural hazard patterns to build a solid repertoire of assets, infrastructure and options that nations can fall back upon. And to be able to do so social policy paradigms have evolved in the recent times combining various approaches that lie at the intersection of disaster risk reduction, climate change adaptation and social protection. However, to be able to realize their full potential, it is necessary to bring their discourse to the regional and local scales, involve several stakeholders, integrate cross cutting themes and deliver them as appropriate programmes while taking full advantage of the emerging tools, methodologies and GIS technologies.

And this requires a practical implementation approach that on the one hand, tracks the technological advances, brings inter disciplinary stakeholders onto a common platform and on the other, undertakes to deliver appropriate ASP programmes with full stakeholder cooperation. Hence, a strong case for a climate smart ASP implementation framework; background of which and whose concept exposition forms the core of the paper.

2 Disaster, climate hotspot programmes

2.1 Disaster risk hotspot project

The World Bank and the Columbia University have developed a report and a global database of natural disaster hotspots early 2005 in conjunction with several global natural disaster risk hotspot project partners and other individuals and groups. (Dilley *et al.*2005), in this report, assess two risk outcomes namely—mortality and economic losses based on the global distribution of six hazards namely- earthquakes, cyclones, landslides, floods, volcanoes and drought. The data inputs comprise past data on hazards outlined above and exposure data related to land area, population, economic activity, agricultural activity and transportation density. Both the input and the exposure data were transformed to include inhabited or agricultural areas, a common resolution of 2.5 arc-minutes and sliced into deciles. Further all six hazard deciles were combined and the top 3 deciles kept. Zonalstats functions were used to calculate exposure values. Hazard specific mortality rates (for disaster risk: mortality) were derived from EM-DAT datasets per 100, 000 persons. These rates were then applied on a per hazard basis to the population in the grid cells of the exposed area to arrive at single hazard mortality layers. The process was repeated for all other five hazards and the results summed to estimate the mortality from all six hazards. Similar process was applied to estimate the disaster risk for economic losses albeit with GDP in the grid cells considered. The economic losses pertaining to each hazard layer were then summed to estimate the economic loss for all six hazards. The data sources, detailed methodology and the results discussion can be accessed from the publications at the Center for Hazards and Risk Research of the Columbia University.

2.2 The climate risk hotspot project

(Andrew & Blois 2008) in a recent study commissioned by CARE International and the UN Office for Humanitarian Affairs (OCHA), attempted to identify regions and communities most likely at risk of specific climate-related disasters. Using Geographical Information Systems (GIS) technology, this study examined the potential humanitarian consequences of climate change during the next 20 to 30 years identifying specific hazards associated with climate change, such as floods, cyclones and droughts and factors influencing human vulnerability. The resulting maps identify hotspots of high humanitarian risk linked to climate change. In terms of the methodology, noteworthy of mention is the vulnerability indicators used across physical, social, human, natural and financial dimensions. Key representatives include physical (road infrastructure, road coverage, and telecommunication), financial (GDP), social (governance, conflict risk, and displacement), human (poverty, health) and natural (agricultural suitability, water availability, land degradation).The study is significant due to its extensive efforts to intersect climate relevant disaster risk (mortality) using past data and future climate model projections with human vulnerability to identify climate risk hotspots.

3 Vulnerability indices

3.1 Environmental vulnerability index

(Kaly *et al.*1999) developed a vulnerability index for the natural environment with the joint collaboration of South Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Programme (UNEP) and their partners and in consultation and collaboration with countries, institutions and experts across the globe. Environmental vulnerability is defined by three sub-indices. These sub-indices focus on ecosystem integrity and how it is threatened by natural and man induced hazards. The EVI uses 50 ‘smart indicators’ to capture the main essence of environmental vulnerability. The term ‘smart indicators’ has been used to define EVI indicators which aim to capture a large number of elements in a complex interactive system while simultaneously showing how the value obtained relates to some ideal condition. Each indicator is further classified into a range of sub-indices including the three aspects of hazards, resistance and damage.

3.2 Social vulnerability index

Prominent among the social vulnerability indices in use across the globe is the SoVI Norway index. This is an index that is constructed based on (Cutter *et al.*2003) *'Hazards-of-Place Model of Vulnerability'* framework that integrates exposure to environmental hazards (with the social conditions that make people vulnerable) and is applied at the municipality level. 27 indicators clustered around 5 principal factors namely—population structure, gender, income, socio-economic status and renters were combined into a composite score to map the social vulnerability of Norway to environmental hazards.

3.3 Economic vulnerability index

(Guillamont, 2008), in his paper *'An Economic Vulnerability Index: Its Design and Use for International Development Policy'*, outlines both the design and purpose of EVI and its complementary use with traditional aid decision measures to identify and support least developed countries (LDCs) with development aid considerations. In line with the design construct outlined in the paper, the EVI incorporates a combination of the following seven indicators: population size, remoteness, merchandise export concentration, share of agriculture, forestry and fisheries in gross domestic product, homelessness owing to natural disasters, instability of agricultural production and, instability of exports of goods and services. They are grouped into two broad areas comprising an exposure index, determined by indicators by the first five and a shock index constructed from the last two indicators The economic vulnerability index is then calculated as an average of the exposure index and shock index. (O'Brien *et al.*2008), by bringing local level and human security angles, add further to the discussion of vulnerability while highlighting the important interdisciplinary research needs of CCA and DRR practitioners.

Thus, from a cross section of the above outlined indices, it becomes evident that the index design involves careful choice of indicator variables, data availability associated with the indicators, the scale of application of the index, the weights to be associated with each indicator variable and the averaging procedure to arrive at a composite score. Despite such challenges, the fact that substantial international efforts are on to construct, refine and use them to drive a variety of decisions ranging from policy to development aid point to the conclusion that they are here to stay and can be effectively utilized when combined with advances in GIS technology.

A detailed methodological analysis of these prominent global projects leads us to discern the following—(a) Temporal and spatial resolutions for risk mapping need to be fine grained and brought down to regional and local level (b)There exists scope to streamline the disparate mapping approaches by disaggregating natural hazards , climate hazards, exposure levels at the time and space scales identified at a) , (c) There exists opportunity to both draw up individual vulnerability indicator maps—namely economic, environmental, social and political and overlay them to arrive at a composite or integrated vulnerability map for a region (d) There exists scope to overlay individual disaster and climate hazard maps to draw up a integrated hazard profile for the region and (e) finally combine the integrated hazard and vulnerability maps with exposure maps to arrive at comprehensive risk hotspots for ASP options application. The following figure summarizes the conclusions of the methodological analysis presented above.

4 Social protection and climate smart disaster management approaches

(Davies *et al.*2008) in their briefing note to the Expert Group to the Commission on Climate Change and Development, Ministry for Foreign Affairs, Sweden, outline social protection as all initiatives that transfer income or assets to the poor, protect the vulnerable against livelihood risks, and enhance the social status and rights of the marginalized. In a similar vein, they argue that climate adaptation involves reducing risks posed by climate change to lives and livelihoods while disaster risk reduction seeks to minimize vulnerabilities, hazards and their concomitant adverse impacts. They then go on to identify and link the social protection, disaster risk reduction and climate adaptation measures drawing on both the conceptual bases and practical evidence across the world.

The synthesis of which leads them to highlight the key messages of social protection, adaptation and DRR into Adaptive Social Protection framework depicted in figure 2.

The developed construct suggests that approaches to social protection have benefits for both adaptation and disaster risk reduction. Following their argument in terms of the typical social protection approaches ranging from provision, prevention, promotion to transformation, the benefits seem to help target the most vulnerable, build capacity to weather shocks, promote risk sharing, help diversify livelihoods and assets that buffer the extreme of weather and natural hazard events. A subset of the projected benefits and their inherent implementation challenges are highlighted through the following figure 3. (Arnal *et al.*2010) seem to corroborate the findings with substantial evidence from the sector.

5 Climate smart disaster risk management

Building on the adaptive social protection paradigm outlined in the earlier sections and the more integrated approaches of Disaster Risk Management through the GFDRR Stockholm Policy Forum 2009 and UNISDR 2009, (Mitchell *et al.*2010) came up with a new and promising construct to disaster risk management through the Climate Smart Disaster Risk Management (CSDRM) approach. Key tenets of the approach include addressing the disaster risk related uncertainties, enhancing adaptive capacity and tackling poverty and vulnerability structural causes. A close look of the approach reveals the following prominent strands of thinking:

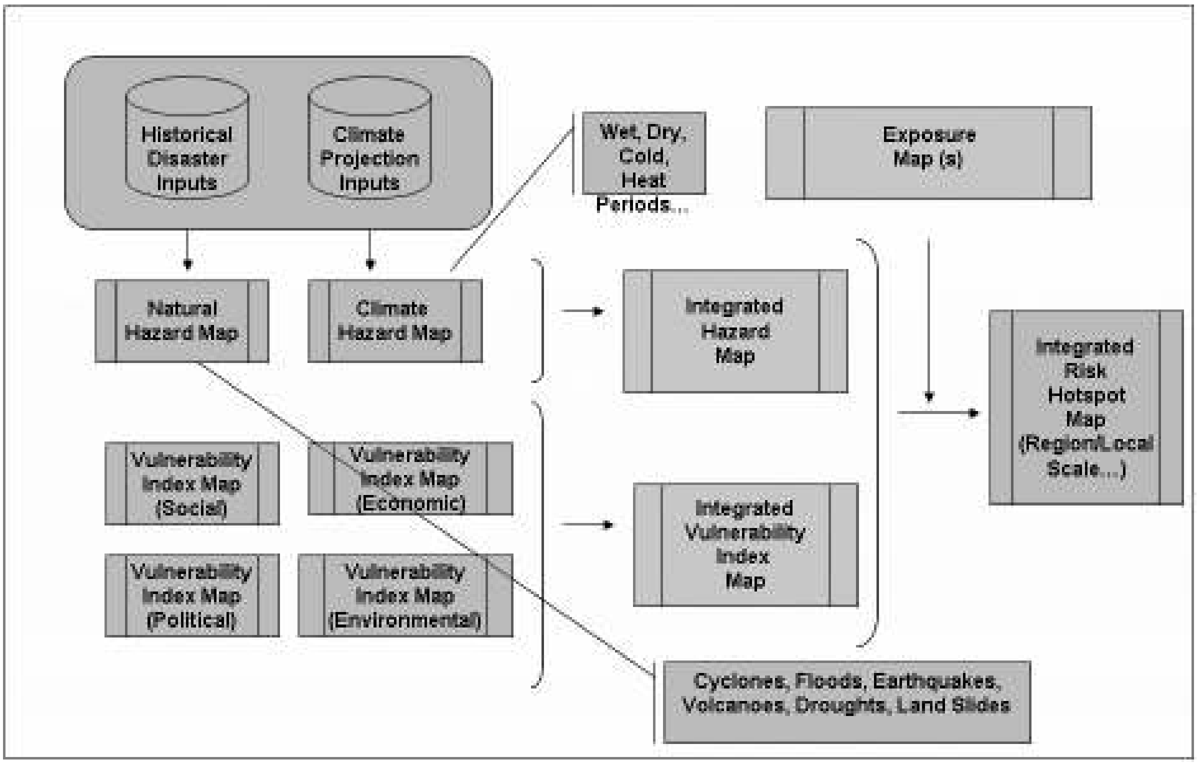

Figure 1. Integrated Risk Hotspotting Analysis.

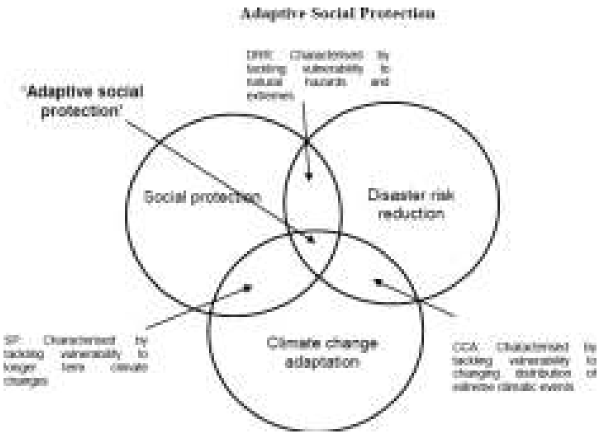

Figure 2. Adaptive Social Protection; Davies *et al.*2009.

- Periodic assessment and incorporation of risks, climate uncertainties into plans, policies and programmes.
- Involvement of diverse stakeholders and keeping them informed in transparent communication loops at all times for effective learning, reflection and innovation.
- Promotion of social, economic, environmental and political justice and climate smart development.

Thus, integrating the arguments, synthesis and analysis of the constructs through the integrated risk hotspotting, adaptive social protection instruments to the climate smart disaster management approaches, results in the comprehensive implementation construct of '*Climate Smart Adaptive Social Protection Implementation Framework*'. Central to this implementation framework are finer resolution of temporal and spatial scales (read regional/local), explicit and comprehensive integration of disaster risks and uncertainties of climate change through the integrated hotspot mapping, choice of ASP instruments (provision, prevention, promotion, transformation) based on the profile of the integrated risk hotspots, greater possibilities to engage with diverse stakeholders, promote justice of all forms and smart development through explicit vulnerability indices mapping and finally integrated them all through local and participatory programme management interventions. In summary the framework, borne out of the synthesis of various constructs, takes the following form and depicted through the following figure.

6 Climate smart adaptive social protection implementation framework

Following the drivers identified in the previous section for the proposed framework, it is pertinent to consider a brief exposition of each of the identified pillars supporting the framework.

6.1 Vulnerability research

The proposed research pillar is primarily aimed at reducing the uncertainty surrounding the science of climate change and providing robust evidence, model, and index based inputs to drive the local ASP programme

Social protection measure	Benefits for adaptation and DRR	Challenges
Employment guarantee scheme	- Provides potential off-farm employment in rural areas - Public works can used as a physical response for building resilience against climate change impacts - Provides a guaranteed income to combat seasonal variation	- One job card per household may not be sufficient to support vulnerable and marginalised individuals - Can negatively impact on agricultural real wages - Lack of awareness means low enrolment rates -Inefficient compared to direct cash transfers
Asset transfers	- Ability to target most vulnerable people - Easily integrated in livelihoods programmes	- Ensuring local appropriateness of assets - Integrating changing nature environmental stresses in asset selection
Social Pensions	- Addressing the dualism of old people being unable to provide for themselves, and high levels of unemployment and very low incomes limiting the ability of the poor to care for their elderly - Targeting most vulnerable to climate change shocks. - Providing a guaranteed household income.	- Cost inefficiencies (arising from inclusion errors) - 'Perverse redistribution of income', as rich people outliving the poor people - High transaction costs

Figure 3. Benefits and challenges of Social Protection for Adaptation and DRR Davies *et al.*2009.

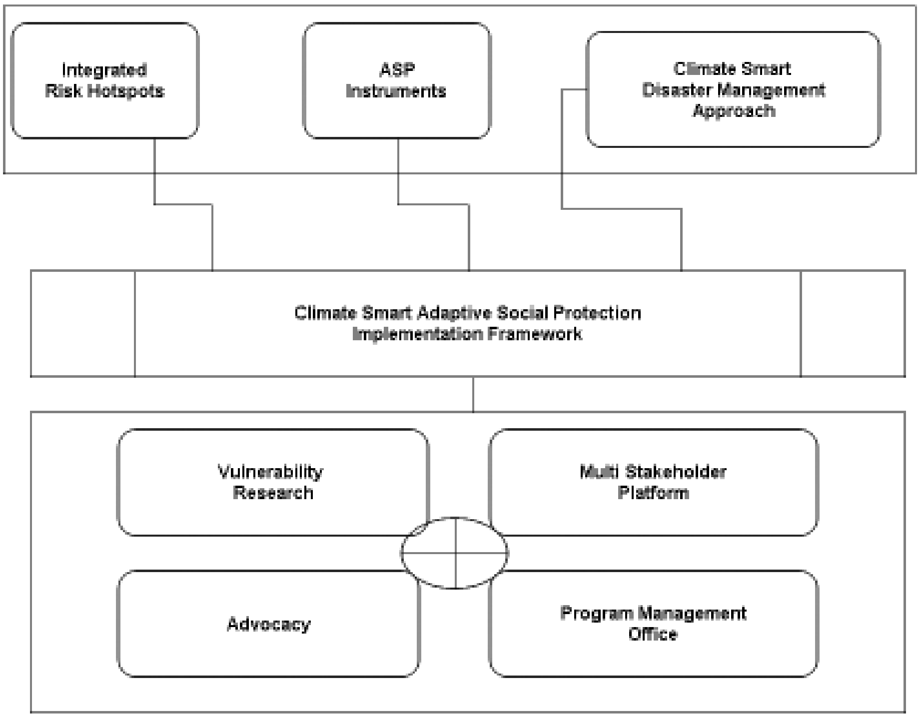

Figure 4. Climate Smart Adaptive Social Protection Implementation Framework. Picture Courtesy: Author

options. To be able to do so not only requires data, processes, tools, approaches and a common pool of skilled resources but also rigorous GIS system adoption in order that the policy and funding choices become effective. Further, such a pillar also provides nodal support to integrate the continuously evolving international know-how and know-what in the realm of vulnerability and climate change domains. In addition, such a pillar provides a context for collaboration and joint up thinking opportunities which form the bedrock of all efforts aimed at adaptation and mitigation efforts of disaster risk reduction and climate change.

6.2 Multi stakeholder platform

The approaches of both adaptive social protection and climate smart disaster management rely heavily on bringing practitioners—development, climate change, disaster risk management, policy makers, individuals, communities, scientific community among others to address the challenges posed by both natural and climate hazards. Clearly, bringing together such diverse stakeholders to a common platform augurs well for seeing visible results of the ASP programmes operating on the ground. Also, such a platform proposes to integrate multiple, diverse view points into a logistic whole to drive key elements of vulnerability research. In addition, it also serves as an ideal ground for a full 360 degree assessment and development of any ASP instruments before being made operational.

6.3 Advocacy

The advocacy mode serves to act as a check against incorrect or short sighted policy choices, looks to forge strong partnerships among stakeholders and most importantly serves to keep the channels of communication open at all times among its constituent participants.

6.4 Programme management office

Depending on the hotspot orientation; ASP programmes options—provision, preservation, promotion or transformation need a fair amount of programmes design and implementation support. Further, integration across the other three pillars, pilots, large scale programmes, funding, execution, reflection and learning from experiences, outreach, impact assessment, course correction as also improvisations all require closed loop coordination through a well defined programme management office.

6.5 Challenges

Despite much promise in such four pillared implementation framework, many challenges are foreseen in operationalizing the concept. Firstly, evidence, science based, decentralized approach to policy and programme evolution across countries. Secondly, the power and influence equations of institutions and their infrastructure, skill and funding power levers can imply an empowered metalayer that is less effective and efficient in driving the true purpose behind the framework. Thirdly, the timelines involved in operationalizing it and finally, execution, long term sustenance of the framework, political and economic will of the governments that tend to be short term in their orientation.

6.6 Conclusion

The extensive background related to the evolution of the 'Climate Smart Adaptive Social Protection Implementation Framework', and exposition of its four pillars and the challenges involved in operationalizing it were covered. Despite them, author believes the concept to present much promise not only in integrating the evolving strands of disaster risk reduction, climate change adaptation and social protection approaches but also in bringing out a clear implementation outlook to kick start possible innovations to build long term resilience of most vulnerable individuals/communities/societies.

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Community-based adaptation to coastal hazards: A scoping study among traditional fishing communities in Kerala, India

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fisheries

ABSTRACT

Traditional fishing communities in India are vulnerable to different types of coastal hazards and related livelihood uncertainties. Moreover, with challenges such as global warming and climate change, these coastal communities have become more susceptible to the vagaries of nature. Taking the case of coastal fishing communities in the southern districts of Kerala, India, this paper explores the adaptation strategies that emerge in the context of environmental changes and coastal hazards. Firstly, this paper examines the nature and impact of coastal hazards on sustainable livelihoods. Secondly, it analyses the nature and consequences of adaptation strategies followed by different stakeholders in coastal resource management with respect to environmental degradation and coastal hazards. The findings of this study show that stakeholders such as state authorities mostly resort to technological adaptation such as the construction of seawalls, breakwaters, and groins. However, these costly interventions seldom take into consideration the livelihood dependencies of traditional fisherfolk on their coastal resources. This paper also shows that such interventions enhance the vulnerability of coastal communities to natural hazards. Territorialisation of fisheries, resource use conflicts, and migration are other visible outcomes of such interventions. This study is qualitative in nature. Data was collected using in-depth interviews. Data was collected from traditional fisherfolk, elected representatives of local governing bodies, and officials from the state departments. The findings of this paper will significantly contribute to existing debates on community-based disaster risk reduction and adaptation strategies.

1 Introduction

There is an urgent need for adaptation studies on communities that are already marginalised and ecologically stressed. Such studies could deliver meaningful insights on potentially larger effects of unplanned adaptation (Adger *et al.*, 2006). Often, it has been observed that past adaptation measures are less reliable (Burton *et al.*, 2006) and current adaptation measures are being designed with the assumption that the climatic conditions and the occurrence of extreme events will be largely consistent with those observed in the past (Burton *et al.*, 2006). Insights on the accuracy and suitability of different levels and types of adaptation in different socio-ecological contexts could facilitate the strengthening of safe livelihoods and ensure food security, when compared with mitigation (Adger *et al.*, 2005; Finan and Nelson, 2001, Narain *et al.*, 2009). In this context, it is very essential to understand the risks that vulnerable people face, their capacity to manage these risks, and what external support they require to strengthen their resilience (Christoplos *et al.*, 2009). It is also very important to analyse how local institutions and organisations affect adaptation and livelihoods (Agrawal, 2008).

The present paper is located in the above-mentioned context. Firstly, it examines the nature and impact of coastal hazards on sustainable livelihoods of traditional fishing communities. Secondly, it analyses the characteristics of both autonomous, community-based adaptation strategies and planned adaptation strategies. This paper then analyses the nature and consequences of respective adaptation strategies followed by different stakeholders with respect to environmental uncertainties and coastal hazards.

2 Theoretical background

Recently, there has been a growing literature on adaptation to environmental uncertainties and natural hazards. Burton *et al.*(2006) has defined adaptation as coping with those impacts that cannot be avoided. Yet a broader definition of adaptation in climate change studies is denoted in terms of adjustments in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities (IFRC, 2009). Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change (Smit, 1993). The term adaptation means any adjustment, whether passive, reactive or anticipatory that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (Stakhiv, 1993 in Klein and Toll, 1997). This paper extends the definition of adaptation to all kinds of environmental uncertainties and hazards. In this paper, adaptation is defined as adjustments made by human and natural systems in response to environmental-livelihood uncertainties and extreme hazard events.

At a macro level, adaptation could be understood as both proactive and reactive (Burton, 2006; IFRC, 2009). Proactive adaptation anticipates future events due to environmental uncertainties or natural hazards. It aims to reduce exposure to future risks; nevertheless it requires greater initial investment but is more effective at reducing future risk and cost (Burton, 2006; IFRC, 2009). Reactive adaptation, on the other hand, is an action in response to the observed environmental uncertainties and their impacts. It aims only to alleviate impacts once they have occurred (Burton, 2006; IFRC, 2009). In several other studies, adaptation has also been classified as planned and autonomous adaptation. The IPCC has distinguished four scales of adaptive capacity: mega (global), macro (national), meso (at community or population group level) and micro (at the level of household or small company). In a general sense, the mega, macro, and meso scales relate to planned adaptation, while some meso and most micro scale adaptation fit the autonomous category (Christoplus *et al.*, 2009). Autonomous adaptation is what the coastal socio-ecological system would do by themselves, whereas ‘planned adaptation’ involves conscious human interference to assist in the persistence of some desirable characteristics of the coastal system (Adger 2000).

In addition, Klein and Tol (1997) have classified adaptation to environmental uncertainties at three levels namely, the strategic level, the population level, and the individual level. Adaptation at the strategic level focuses on the development and implementation of policies aimed at changing populations’ and individuals’ attitude towards climate change. Adaptation strategies can serve two purposes at the population level namely, to reduce disaster risks and to facilitate adaptation by individuals. Adaptation at the individual level focuses mainly on behavioural adjustments aimed at limiting dangerous exposure (Klein and Tol, 1997). It could thus be understood that a combination of adaptation levels exist at a specific socio-ecological context. For instance, in a study that analysed the response to the hurricanes in the Carribean, Cayman Islands, Adger et al (2005) have observed that adaptations included (i) changes in the rules and governance of hurricane risk, (ii) change in organisations, (iii) establishment of early warning systems, and promotion of self-mobilisation in civil society and private corporations.

This paper has also drawn considerable theoretical insights on adaptation specific to coastal hazards. There are three possible options of coastal adaptation namely (i) protect, (ii) accommodate, and (iii) retreat (Biljsma et al, 1996). In protect, the response aims to protect the land from the sea so that existing land uses can continue by constructing hard structures such as seawalls as well as using soft measures such as beach nourishment. On the other hand, accommodation implies that people continue to occupy the land but make some adjustments. For example, the generally observed adaptation include elevating buildings on piles, growing flood or salt tolerant crops etc. An extreme adaptation strategy is that of retreat which involves no attempts to protect the land from the sea. This could finally also result in the abandoning of the coastal area (Biljsma *et al.*, 1996). Studies have also observed that some adaptation measures handle uncertainty better than others. For example, Adger (2000) notes that beach nourishment can be implemented as relative sea level rises and is more flexible than a dike or a sea wall. He also notes that any shift from hard structures such as sea walls to soft shore protection measures such as beach nourishment must be accompanied however by a much better understanding of coastal processes that prevail in the area (Adger, 2000).

3 Methodology

Drawing from the above theoretical discussions, this paper examines the characteristics of both autonomous and planned adaption to coastal hazards. It has attempted to examine the level of adaption from the household level, community level and the regional/ administrative level. The underlying research design for this paper has been qualitative in nature. Data was collected from the traditional fishing households in Eravipuram, Kollam district. Fieldwork for the study was conducted between June 2009 and November 2010. Data was collected through in-depth interviews. A total

Table 1. Chronological history of hazards that affected Eravipuram.

Year	Hazard
1970	Encroachment of the sea
1974	Flood
1975	Communal riot
1993	Communal riot
1994	Tidal waves
2001	Encroachment of the sea
2002	Tidal waves
2003	Encroachment of the sea
2004	Encroachment of the sea, Tsunami
2005	Encroachment of the sea
2006	Sea Erosion
2007	Sea Erosion, Swell waves
2008	Sea Erosion, Encroachment of the sea
2009	Sea Erosion, Encroachment of the sea
2010	Sea Erosion, Encroachment of the sea

of 35 households were interviewed. Purposive sampling was used to identify the coastal village and snow-ball sampling was used to identify the respondents. Both men and women in households were considered as respondents. Focused group discussions were also carried to substantiate the findings drawn out of the household interviews. A total of four focused group discussions were conducted. Data was also collected from the officials in respective state departments regarding planned adaptation strategies. Interview guides were used to conduct the study. A total of 10 interviews were carried out for the same. The findings of this paper are analysed based on qualitative analytical methods such as coding, pattern coding, memos, summary sheets, tabulation etc. The key findings of this paper are discussed in the next section.

4 Findings

4.1 Coastal hazards and their impact on sustainable livelihoods

Eravipuram is a fishing village that is very much exposed to different kinds of coastal hazards. Some of the hazards that the community faces today are increased coastal erosion, coastal inundation, episodic sea flooding, landward intrusion of saline ground water, increasing 'coastal squeeze', increased rates and frequency of episodic wave run-up, swell waves, and communal riots. This village was also affected by the Indian Ocean Tsunami that struck the Kerala coast in 2004. Table 1 and Figure 1 depict the chronological history of hazards that affected the village. Figure one demonstrates that the frequency of coastal hazards have increased since 2000.

Local communities have developed their own understanding on the nature of hazards, their causes and impacts. Villagers observe that in the past eight years, more than 500–800 metres of the beach has vanished due to coastal erosion. During the rainy season, the remaining fifty metres of the beach also disappears. They attribute both man-made and natural causes to the erosion of the coast. A significant factor that has led to severe coastal erosion has been due to ill-conceived shoreline protection works and harbour development works in neighbouring coasts that are a few kilometres away. These shoreline protection works such as groins/breakwaters (locally known as *pulimuutu*) have worsened and shifted the erosion problems in their coast. Ill-conceived groin structures while stablising a beach on the updrift side could aggravate erosion on the down drift side. These structures also increase the wave run-up height.

Fishing communities in the neighbouring regions comment that the sudden rise in the construction of sea-walls and groins has increased coastal erosion in many areas. There are instances where the coastlines that have historically been eroding are experiencing increasing erosion trends. In addition, those areas that were relatively stable are beginning to erode. Such developments are increasing the phenomenon of coastal squeeze, where shorelines are held and constrained by structures such as groins and seawalls. These have also led to a considerable reduction of inter-tidal area and loss of beach. A drastic increase in the frequencies of episodic sea flooding and resulting coastal inundation is also being reported. These wave run-ups overtop both natural and man-made coastal defences. There are also reports of swell waves occurring in this region. It has to be noted that these communities were very much affected by the Indian Ocean tsunami that hit the coast in 2004. Around 108 houses in the village were fully destroyed by the tsunami. However, villagers today consider the coastal erosion and storms as threatening hazards than the tsunami. The frequent high waves and swells destabilise and moves large quantities of sediments, leading to erosion, coastal inundation and structural damage.

Yet another problem that the villagers face is the salinisation of drinking water sources. Prior, to the tsunami, these villages have never faced any scarcity of fresh drinking water. However, off late, their ground water sources such as wells have been worse affected by salinity problems and depletion of ground water levels. Severe hygienic and health problems are also reported in the village. The space to dispose marine/fishing waste (such as remains of aquatic organisms, weeds, worn out fishing gears, plastics and nylon threads etc.) have considerably reduced with the erosion of the coastline. These days, the waste gets accumulated amidst the human habitation resulting in the spread of epidemics.

Debates on climate change and related hazards have often focused on coastal hazards. It is understood that though climate change will not introduce any new types of coastal hazards, it will affect existing hazards by changing some hazard drivers. Moreover, localities such as Eravipuram that are currently exposed to a series of coastal hazards are likely to suffer increased risks with a warming climate. For example, fisherfolk in Eravipuram recollect that they had to face a rough sea and strong currents, only during the monsoon months of May and

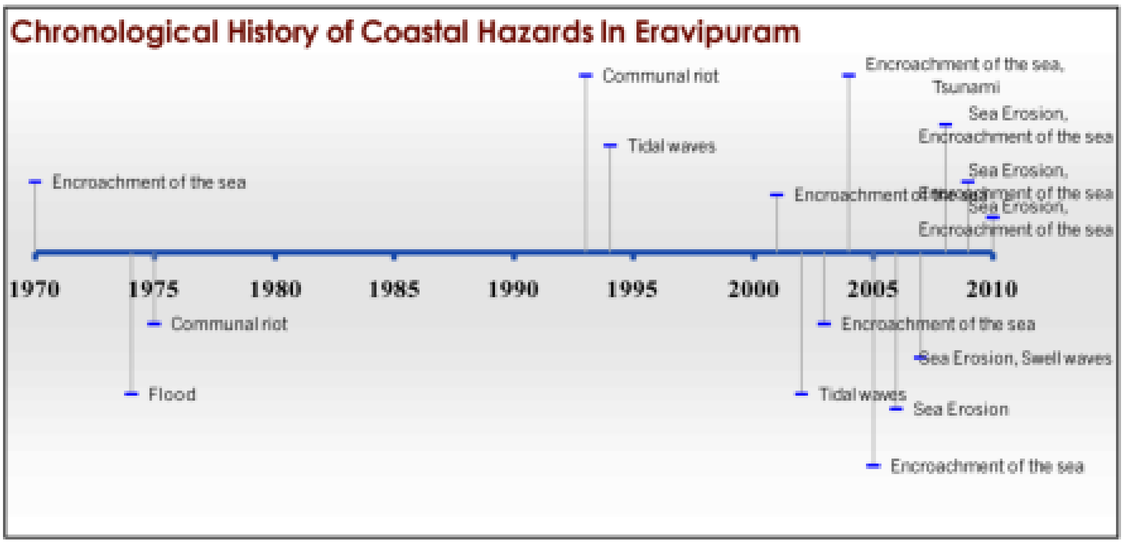

Figure 1. History of coastal hazards, Eravipuram, India.

June. However, these days they have to face strong oceanic currents during the months of December and January as well. Local communities observe that rising sea levels and resultant damage to infrastructure has become a regular phenomenon after the tsunami. They attribute such changes to the changing weather conditions, the tsunami and ill-conceived structures such as the groins and seawall.

The above-mentioned coastal hazards impact on all the three spheres of sustainable livelihoods namely, the environmental, economic and social spheres. The risks generated in these three spheres due to the coastal hazards are often interrelated, dynamic and add up to the progression of vulnerability among traditional fishing communities . These impacts are elaborated as follows. Coastal hazards in Eravipuram have resulted in the manifestation of different kinds of environmental risk. There has been a massive erosion of the beach. This has also resulted in the loss of regular fishing grounds for the fisherfolk in Eravipuram. This is mainly because of the fact that they are unable to sail off to these fishing grounds from their own shore. Elders in the village observe that the regular breeding practices of aquatic organisms in the region have severely been affected due to changes in the resource system. They attribute factors such as construction of ill-conceived groins at the mouth of estuaries, blockage of fish passages to inland waters, mining by industries, dumping of toxic waste into water bodies as causes of change in fish breeding habits. With the intensity and frequency of high waves on the rise, there has also been considerable destruction of natural and artificial defences such as coastal vegetation and man-made seawalls respectively. It is also observed that increase in coastal erosion and destruction of coastal defences has led to the salinisation of drinking water sources in the villages. Most of the wells that used provide fresh water is now saline.

The various coastal hazards along with environmental degradation have impacted upon the economic spheres too. Destruction of houses and roads from severe waves and erosion has become a common feature along the coast of Eravipuram. Communities are forced to spend extensively on rebuilding their homes or in relocating themselves to safer places. In addition, coastal hazards such as strong waves during the rainy season destroy the existing facilities such as cold storage to preserve their catch. This happens especially when the waves destroy the power supply. As mentioned earlier, the sea walls and groins have themselves turned out to be ineffective. However, the regular maintenance and construction of these structures have become very costly affairs for the local governing bodies. The beach was earlier a common property that helped fisherfolk to land their catch in their own shores. This helped them to sell their fish at fair prices to their regular fish merchants. It also provided them enough bargaining spaces to arrive at fair prices. In a similar vein, due to coastal erosion, they have also lost the spaces for resting their catamarans and maintaining their fishing gears. Today, the fisherfolk are forced to rest their canoes and catamaran at beaches faraway from their village. This very much affects the safety and security of their fishing crafts and gears. Moreover, it adds extra financial burden for their transportation to these places. There are also instances where the strong currents have destroyed the catamarans and fishing gears worsening the financial burden among the fisherfolk. Due to all these reasons many fisherfolk have also shifted from fishing to other occupation such as selling fish.

The social life of fisherfolk has been considerably affected with the erosion of the coast. Earlier they used to celebrate their festivals in the beach. However, these days they are unable to do so with the erosion of the coast. The relocation of houses has also affected their joint family structure. Today, these families stay scattered across vulnerable locations. The changes in family structures have also been facilitated due to the shift in the fishing crafts that they used to fish. Earlier, the fishermen used to sail in canoes that were big enough to carry three-four men. So the members of the joint families used to venture out together for fishing. However, as the waves have become stronger the traditional canoes made of wooden planks (such as *ilavu* or *murikku*) were not sufficient to withstand their force. The fishers therefore shifted to catamarans made of fibre. However, these catamarans could not accommodate more than two fishers. As a result more and more fishers went out fishing separately. This also motivated them to stay as separate nuclear families.

The erosion of the coast and the consequent loss of fishing spaces have resulted in the re-territorialisation of fishing spaces. Earlier fishermen used to fish from the sea in front of their village. For the same, they used to sail off from their own coast. However, with the disappearance of the beach they had to set off from other shores. However, that also implied that their own fishing spaces were far off from them. In the mean time, fishermen from other villages have begun to occupy these fishing spaces. This has often resulted in conflicts between fisherfolk.

As evacuation has become an annual feature, the insecurity of people has also gone high. This is because lot of theft occurs during the evacuation and when people are located in the temporary shelters. In addition, the schools in the locality are often used as the temporary shelters. This has in turn affected the regular classes of school children in the village. The accumulation of waste amidst the human habitats has also resulted in the emergence of infectious diseases and epidemics in the region. Having discussed the nature of coastal hazards and their impact on coastal livelihoods, the following section looks at how local fishing communities adjust or respond to environmental/livelihood uncertainties and extreme hazard events.

4.2 Characteristics of community-based adaptation strategies [autonomous adaptation]

The focus of this section of the paper is to examine adaptation at micro-level, namely the adaptation of a particular coastal fishing community to environmental uncertainties and coastal hazards. Due to the same reason the theoretical background of this section is centred on livelihood adaption. Agrawal (2008) has classified livelihood adaptation strategies as (i) mobility, (ii) storage, (iii) diversification, (iv) communal pooling, and (v) market exchange. While 'mobility' as an adaptation strategy has been denoted as an adaptation response across space, storage reflects adaptation with respect to time. 'Diversification' could be understood as an adaptation strategy across asset classes, while 'communal pooling' refers to the sharing of resources across households (Agrawal, 2008). The author in his analyses claims that 'market exchanges' can substitute the four strategies, if the community has sufficient access to market (Agrawal, 2008).

Mobility as an adaptation strategy is the most common response and pools risk across space (Agrawal, 2008). While storage is an adaptation strategy that pools and reduces risk across time, it is mostly utilised by communities that face severe food and water scarcities. Diversification as an adaptation strategy deals with productive and non-productive assets and is focused more towards consumption strategies and generating alternate employment opportunities (Agrawal, 2008). Agrawal (2008) explains communal pooling as the joint ownership of assets and resources, and the mobilization and use of resources that are held collectively during times of scarcity. It includes sharing of wealth, labour and income across households and spreads risks across households (Agrawal, 2008).

In the present study, the adaptation strategies are manifested in terms of their belief systems, migration and occupational shifts, developing new/alternate fishing skills, changes in traditional fishing boundaries, alterations in fishing crafts and gears, varying use of local knowledge systems etc. Some of the major livelihood adaptation strategies are discussed below.

4.2.1 Mobility

Subsequent to coastal erosion, rocks have emerged at the shore. This has prevented the fishermen from smoothly launching their catamaran. [This phenomenon is again related to the side-effects of planned adaptation along the Kollam coast. To check coastal erosion, the government has implemented in a large scale the construction of sea walls along the coast, including Eravipuram. However, due to unscientific construction of these sea walls, most of the rocks that were used to construct the walls are today engulfed by the sea. This has prevented the fishermen to set off in their catamaran from their own coast.] In addition, the sea waves in this side of the coast have become stronger and heavier, causing lot of difficulties to the catamaran fisher-folk. Sailing off to fish from such a coast actually results in lot of accidents such as head injuries. Consequently, many fisher-folk have shifted their fishing locations several kilometres away towards the northern direction from their village. As the rainy season approaches, almost all the fishermen leave their coast and fish from the Neendakara estuary. This shift has some consequences. Firstly, fishermen have to row their crafts to longer distances, which also results in physical and mental exhaustion. Secondly, this shift also trespasses into traditional fishing boundaries of fisherfolk from other neighbouring villages. During times of resource scarcity, these are potential platforms for conflicts. As Catamaran fishing has become difficult, fisherfolk migrate to the fishing harbours in search of work. On the other hand, fishermen from other villages fish in their fishing boundaries. While it is not possible for the natives to sail off from their own coast, it is possible for outsiders to reach their waters from their respective coasts. This often results in conflicts between the natives and the outsiders. The same thing happens when the natives of Eravipuram migrate to other fishing villages for their survival.

Environmental uncertainties and the increase in frequencies of coastal hazards have also forced many youngsters in the community to try out other jobs. Many among the youth migrate to the city centres in search of wage labour. However, there are limitations to such adaptation strategies as well. Firstly, many lack the necessary skill and expertise to shift to other occupations. Moreover, many people who shift to such occupation find it difficult to sustain in the new job as they feel that it lacks essential freedom or autonomy in their job. Yet another important observation is that such occupational shift is highly age-dependent. While the youth are able to easily shift to other jobs, the elderly population finds it difficult to shift to other jobs. Instead, they borrow money from money lenders at a higher interest rate and thus increase their debt burden.

4.2.2 Diversification

One striking observation has been that fisherfolk cling on to the same livelihood sources even after being threatened by various kinds of hazards. However, within the realm of fishing, they have attempted to diversify their fishing skills and technology. Their local knowledge base and understanding of coastal hazards is the basic resource that influences their diversification strategies. For instance, communities observe that there are chances of a good fish catch during strong tidal currents. Though it is of high risk to venture into sea during such tough times, some fishermen have developed specialized skills to fish and swim in troubled waters. Occasionally, when the wind is very strong, the fishermen take a plank and place it under water and tie it with a rope on the two sides of the canoe so as to maintain their balance. However, if the wind is too strong, fishermen are forced to leave without picking up their fishing gears.

In a similar vein, fisherfolk also use their local experiences and understanding to predict environmental uncertainties and natural hazards. The community reveals that the reliance on such local knowledge has gained a lot of significance these days. For instance, they do not sail off to the sea for fishing, if the sea currents are taller and stronger during morning time. As per their understanding, such sea waves indicate the emergence of storms and rise in sea level. Similarly, during the month of June-August, if the sea shore (soil) becomes loose, then the probability of huge sea waves lashing at the shore is very high. If the variety of fish available changes suddenly, it also indicates danger. Fisherfolk also predict storms by observing the behavioural changes of crabs and sea snakes. If the crabs move towards inland in large numbers, it indicates the rise in sea level. Similarly, one could predict the arrival of a storm, if the sea-snake acquires the shape of a ball and float in the surface of water. In a similar vein, the rapid presence of red sea worms in the surface of sea indicates danger. Fisherfolk also collect information from toddy tappers regarding sea-level rise. Toddy tappers will predict the rise in sea level, by looking at the quantity of toddy they harvest from the coconut trees planted along the shore. On a particular, the more they harvest from a tree, the greater is the probability of sea-intrusion.

Fishermen have also developed new kinds of local knowledge that warns them of sea level rise or of a fish catch. Fishermen these days know that strong tidal waves bring lot of fish. They also note that the colour of sea changes according to the type of fish. If the sea appears green in colour then it indicates that the availability is less. Especially it is bad news for the hook and line fishermen. If the sea is blue, it denotes that more fish is available. Fisherfolk also observe fish movements based on the flight of birds such as *karivandu*. With the disappearance of the shore, many catamaran fisherfolk find it difficult to sail off to fish in the catamaran. Moreover, with the appearance of the rocks along the coast, it has become very difficult for them to move from one place to another with the net and catamaran. Consequently, the use of *kampa vala* has become a regular feature these days. It is a technique to capture the fish from the shore itself. Some use the *moral vala.* Some fisherfolk have also attempted to alter the material they use for building their canoes. Earlier the crafts were made of *elavu* or *murikku,* which were locally available. However, as the catamaran began to collapse in the strong waves or by colliding with the rocks, they have started to use fibre boats.

4.2.3 Risk pooling

In the above-mentioned context, it has also been observed that the fisherfolk have their own justifications in some of their day-to-day practices. For example, the fisherfolk consider gambling and drinking as a major stress releaser. However, they also accept the fact that in the long term, it adds up to their vulnerability. Yet another common belief is that the tsunami happened because of the misuse of the wealth given by the sea. Apart from these, there has also been a reorientation of the issues that govern collective action among the fisherfolk. Today, hazards and disaster risk issues are a major component of the public protests organised by the fisherfolk. It could be understood from the field visit that the protests and complaints from the fishing community have forced the government to begin consultations on building the sea wall. In yet another development, the catamaran union has requested the government to arrange sand bags in the sea shore for resting the catamarans. In the post-tsunami context, the formation of self-help groups (SHGs) has become one of the most common strategies in risk pooling. However, often they remain as money circulating agencies rather than organisations of entrepreneurial or self-help nature. Often, they also lack cultural sensitivity and fail towards diversifying livelihood opportunities. For instance an SHG for men was started after the tsunami. However, it is not functioning well as its members go for work and do not meet frequently. The discussion on the effectiveness of SHGs and institutional pluralism resulting out of the same is not within the purview of this paper.

4.3 Characteristics of planned adaptation strategies

While the above section dealt with autonomous and community-based adaptation strategies, the current section examines the characteristics of planned adaptation strategies. However, it has to be noted that there are overlaps and interfaces between the planned and autonomous nature of adaptation. Therefore, it should never be taken for granted that both the adaptation types are isolated entities.

4.3.1 Enhanced role of formal governance structures

One of the major responses of the state to recurrent natural disasters has been the constitution of formal governance structures to address hazard risk. However, as of today, these formal structures of risk governance have very limited resources for meaningful disaster risk reduction. Though, a District Level Emergency Operations Centre has been constituted, this agency lacks permanent staff for its day-to-day operation. The government has also constituted a district level committee to monitor the DRR plans of the city. However, they meet once or twice in a year. So far, one of the thrust areas has been towards the organising of several short-term training programmes, whose impacts are often minimal and target oriented. A matter of appreciation is that the government has initiated the preparation of the District-level Risk Reduction plans. However, looking at the history of planning and its implementation in the region, it is doubtful to what extent the plans will be operationalised.

Disaster response and relief has become one of the major components of the Corporation's annual activities. The corporation provides financial assistance to those affected by coastal hazards. Most of these funds are meant for purchasing new fishing gears and crafts. When hazards strike, the corporation provides food materials for the affected communities and also relocates the affected to a safer site. While the focus of the local governance structures are more towards disaster response and relief, a strong observation is that if a major disaster happens again in the region, there are no sufficient technical and financial mechanisms that are locally available to prevent large scale casualties. Even today, there are vulnerable groups who have to walk at least three kilometres to the nearest primary health centres. On the other hand, these health centres have limited in-patient facilities.

As part of disaster response, the government has implemented a housing scheme called Samagra. It provides Rs. 250, 000 to build houses for those who had lost their houses in the tsunami or due to rise in sea-level. The work is generally allotted to contractors who are not at all accountable to the work assigned. If anyone voices their complaints against their corrupt practices, the contractors or their agents provide the reply that the 'fisherfolk do not have any right to question us as it is not their money'. Local communities are of the opinion that in most cases, the full amount is not used for the construction. The quality of houses does not meet the user aspirations and needs. The women are not satisfied with the houses as it does not have any stove. Most of the houses constructed are cracked and leak during the monsoons. Some structures are prone to sea induced flooding. In a similar vein, the catamaran issued by the government was given to people above 60 years of age. However, most of them were unable to row in that, and therefore had to sell them off. The catamarans are useful for single fishermen. But the elders do not prefer to fish alone. Many elders suffer from diseases like eye infections, back ache, and swelling in the knee.

4.3.2 Techno-centric adaptation

One of the most striking features of planned adaptation to coastal hazards is the attempt by authorities to opt for costly technological structures. Lot of investment is being made on long stretches of seawalls, groins and breakwaters with the assumption that they could prevent sea level rise and intrusion. However, a scientific observation is that while the seawall or groin at one end could halt soil erosion, it could accelerate the erosion of the beach in some other neighbouring regions. Eravipuram is one such affected village. Elder fishermen are also apprehensive about the effectiveness of such large scale costly structures. For, they have seen that such structures were even built earlier and most of them have been destroyed by the sea. Unscientific construction and lack of annual maintenance have actually worsened the nature of coastal hazards in the region. However, the younger generation of fisherfolk are forced to believe that structures like sea walls and groins could only now, save their village from being swallowed by the sea. Elected representatives in the region however maintain that it is not the effectiveness that matters. On the other hand, it is the cost of the project and the employment generated that should be considered as an attractive feature of the seawall or groin projects. In the words of the village councillor, "Why should one worry about the permanence and effectiveness of such structures? One should not blind his or her eyes towards a twenty crore rupees worth project coming to his or her village."

The government has hired a contractor to construct the seawall. However, the government has asked the contractor to go ahead with the construction without settling his bills. Nevertheless, the labour and material cost is very high that has forced the contractor to halt the construction without completion. Consequently, a large stretch of the unfinished sea wall is today consumed by the sea. Amidst such processes, there are also proposals to construct groins in the region. Elderly people in Eravipuram observe that the groins constructed near the neighbouring village Vadi has not only accelerated coastal erosion in Eravipuram but also has led to the depletion of fish varieties in their fishing boundaries. As mentioned earlier, they are also unable to use their traditional fishing gears and crafts to fish from their coast. In the above-mentioned context, the catamaran union has requested the government to arrange sand bags in the sea shore for resting the catamarans. They have also requested for the construction of the *groins* in their coast as well, with the assumption that it will reduce the tidal waves, and there by lead to the re-emergence of the beach.

Quite interestingly, the government has launched a beach nourishment programme using vegetative barriers after the 2004 Indian Ocean Tsunami. Naming it as the 'harita theeram scheme', lot of investment has been made in the neighbouring villages towards the planting of casuarina trees along the coast. Though this is a much cheaper strategy and has contributed to a great extent in controlling wind speed, it has been implemented without effective community participation. Consequently, many men have begun to cut these trees, sell them for liquor or have used them as Christmas trees. In many places, there are no spaces for vegetative adaptation. Therefore sea walls are constructed. The practice of filling gunny bags with coir dust has also started in some place, though the effectiveness of such steps has not yet been proved.

5 Discussion

This paper has attempted to examine the nature of coastal hazards affecting traditional fishing communities in Eravipuram. It has also specifically analysed the characteristics of community-based (autonomous) and state-sponsored (planned) adaptation strategies in response to environmental uncertainties and coastal hazards in the region. Some of the important outcomes of the observations made in this paper are discussed as follows.

Compared to the situation ten years before, coastal fishing communities are today more vulnerable to different kinds of extreme coastal hazards. The frequency and magnitude of coastal hazards have increased to such an extent that it affects the very survival of many traditional fishing communities. Both natural and man-made factors can be attributed to the rise in such events. However, the role of anthropogenic and institutional factors in short sighted development planning and highly unscientific coastal zone management can never be undermined. The various stakeholders involved in coastal zone management and disaster risk reduction have not yet bothered to acknowledge the impacts of such interventions on coastal resources and on the livelihood of traditional fisherfolk. The net result is an ever-increasing investment on massive techno-centric adaptation measures, often with very poor returns and sometimes exacerbating the nature of coastal hazards. Such practices often contribute to unsustainable livelihoods as well as result in territorialisation of fisheries in the regions and conflicts between various resource users. As pointed out by Christoplus *et al.*(2009), adaptation strategies can contribute to downward spirals. For instance, people affected by environmental uncertainties could accelerate ecosystem degradation and in addition, external maladaptive measures can rapidly undermine the resource base of local communities (Christoplus *et al.*, 2009).

The manner in which adaptation processes emerge and sustain depends on several factors. The demographic and cultural characteristics of the community decide on the type and extent of opportunities available for adaptation. While the local knowledge remains as an asset for the elders in the community to diversify their opportunities, the youngsters find it comfortable to resort to mobility as an adaptive strategy. However, it is the larger set of economic and political factors and the social networks that operate within these institutions that finally shape and decide the outcomes of both micro and macro level adaptation strategies. The social and economic endowments of households and communities, their ecological location, their networks of social and institutional relationships, institutional articulation and access to resources and power are some of the determinants of adaptation practices (Agrawal, 2008).

The adaptive capacity of coastal communities to cope with environmental uncertainties and extreme hazard events may be less, if there is a lack of physical, economic and institutional capacities to reduce such risks (Nicholls *et al.*, 2007). Planned adaptation projects to a large extent lack community acceptance and collective consensus among a large number of resource users and the project implementers. Earlier studies have observed that most adaptation projects are today unsustainable due to the failure of government agencies to involve the local communities in these projects (Narain *et al.*, 2009). Involvement of local authorities and community-based organisation in the development of adaptation strategies are crucial (IFRC, 2009). Apart from these, some of the major impediments to effective adaptation are (i) lack of systematic data on monitoring coastal hazards and its impact on coastal population and resources (ii) highly unscientific and inappropriate coastal protection measures; (iii) lack of a clear coastal management strategy that integrates risk reduction and sustainable development as part of planned adaptation, (iv) reliance on costly and alien technological structures without taking into consideration the local contexts and livelihood options, and (v) highly insensitive and poor structures of governance.

More and more adaptive responses will be required in coastal zones to cope with a range of increasing hazards arising as a result of global environmental change (Adger *et al.*, 2005). This paper concludes its discussion by emphasising that adaptation initiatives can be improved by providing greater space for local communities and institutions in designing and shaping macro-level adaptation measures. For the same, planned adaptation measures need to be more culturally and historically rooted and at the same time attempt to integrate community-based adaptation strategies into planned development.

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SW monsoon induced debris slides of the arterial roads of Karamana River basin

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Abstract

Slope instabilities manifesting quickly and suddenly in the form of debris slides, landslips and landslides are natural hazards affecting the landscapes, particularly following a high intensity rain fall event. The loci of potential slides are regions and sites where the toe of a slope has been removed either by natural process (erosion by flood waters) or by anthropogenic causes (e.g., a cutting on a hill slope to lay a road or rail road or build a recreation arena or establishing a new township). Any cut and removal of the natural support at the toe of a hill tends induce a potential for frequent landslips, debris slides or landslides. Other natural causes of these forms of rapid mass wasting processes are natural disasters like earthquakes, volcanoes, wildfires, and floods. Excessive and intense rain has been identified as one of the immediate triggers of all categories of rapid mass wasting processes, including landslides, causing life and property damages, disruption traffic flow, sedimentation in farmlands and loss of crops and income to the farmer. Therefore, it is not unusual for landslides and similar mass movements to find a prominent place in the newspaper columns. In a monsoon climate dominated country like India, the states of Himachal Pradesh, the lesser Himalayan region, Nilgris of TN in south India and of late the sector of the western Ghats in Kerala are known for the landslide risk as well as incidence of some of the disastrous landslips and landslides. The rugged, moderate to high relief regions are ideal sites for such events especially after the heavy precipitations associated with the monsoons. In Kerala, midland (7.5–75.0m) and occasionally lower highland (>75.0 m) regions face one or two major events of landslides, of one type or other, and that too during the SW monsoon season that normally commences from between June 1st and extending up to September 30th. A case in point is the year 2007 - an *year of landslides in Kerala*- as the rain fall exceeded by 30% of the normal during the SW monsoon (Muraleedharan and Muraleedharan, 2008).

1 Anthropogenic interventions

During the past century, Kerala witnessed clear felling of natural and forest vegetation in the high land by British Raj to extract timber for export and for indigenous use, especially as railway sleepers, as well as for establishing plantations of tea, cardamom and coffee in the higher altitudes, and rubber in the lower altitude of the lower highland and midland. This period also saw a enormous increase in population and consequent rapid urbanization of the lowland and midland regions. Urban centres sprouted and grew initially along the side's navigable water courses, new roads and in the neighbourhood of their nodes. During the course of time these were gradually extended to the interior (midland and low highland zones). As a result of this and the growing economic activity in the hinterland extension and growth of road network further inland, became an urgent requirement.

This trend of clearing and conversion of vast areas of forests and grass lands and increasing replacement with monoculture destroyed the pristine floral biodiversity of the western flanks of Western Ghats. Contour bunding

Table 1. Road Side Debris Slides in Karamana River Basin during November 2010.

Sl. No.	Location	Location: Latitude	Location: Longitude	Slope category	Orientation and Direction	Length (m)	Height (m)	Approximate amount of debris	Type of material if any	Casualties
1	Karakulam	8°62′03″	76°99′20″	58°	Parallel to the road	2.6	4.9	65	Laterite	Nil
2	Aruvikkara	8°62′42″	76°99′46″	60°	Parallel to the road	3.2	5.2	55-60	Laterite	Nil
3	Vellanad	8°59′16″	77°21′94″	62°	Parallel to the road	3.1	6.2	45-50	Laterite	Nil
4	Vidura	8°49′67″	77°85′62″	71°	Parallel to the road	2.6	5.1	35-40	Laterite	Nil
5	Parandode	8°61′33″	77°35′02″	64°	Parallel to the road	2.2	3.1	45-50	Laterite	Nil
6	Peppara	8°62′44″	77°13′64″	65°	Parallel to the road	2.6	5.1	60-70	Laterite	Nil Some debris fell over an auto rickshaw
7	Bonnacaurd	8°67′44″	77°36′01″	59°	Inclined to the road	1.8	6.1	35-40	Laterite with unweathered boulders	Nil
8	Chanthanpara	8°66′37″	77°15′26″	66°	Parallel to the road	2.2	5.1	55-60	Laterite with unweathered boulders	Nil Affected some pedestrians

in steeper slopes, often interfering with natural drainage lines can be identified as a common feature in the newly settled regions of high land. All these jointly contributed to various forms of rapid and/or slow mass wasting processes in midland and highland. It is estimated that out of the total area of 38,863km^2 of the state, the Western Ghats occupies about 1800 km^2. Of this 1400 km^{2}is considered as critical zone of mass movements.

In this paper, we examine the phenomenon of debris slides that occurred during the wet days of 2010 in the Karamana river basin especially along some of the arterial roads that link the larger urban areas within and outside the basin. But for the major landslides in 1992, in the periphery of the Peppara Reservoir and lesser ones at Thennur and Peringammala, no major slides are reported from the basin. However, geomorphological indications of past, rapid mass movements, of varied types are recognizable in several localities along the upper reaches of the basin in the midland and highland zones. Table 1 gives the list of debris flow spots in the Karamana basin.

2 Geomorphic setting

The Karamana Basin (KB) in Thiruvananthapuram District with an aerial spread of 702 km^2 (Centre for Water Resources Development & Management 2010) is located between N. Lat. 8°21′ 49″ and 8°40′55″ and E. Long 76°49′46″ and 77°14′35″ (see SOI tope sheet No. 58H/2, 58H/3, 58D/14, and 58D/15). The main stem of the river net, the Karamana River has a length of 68 km. The annual water yield is estimated at 836 MCMs and the annual utilizable water is estimated at 462 MCMs (KSLUB, 1995). In terms of the basinal area, of the west flowing rivers of Kerala, KB ranks 15th position. The western margin of its basin coincides with parts of the eastern boundary of the Tambraparni River Basin of Tamil Nadu, which more or less forms the crest of the Western Ghats, where one of the peaks named 'Chemmunji Mottai' (1717 m above MSL) forms the source of the Karamana River.

3 Geologic makeup

The KB lying in the southern Khondalite Belt is characterized by the khondalites, i.e., mostly metasedimentary, garnetiferous quartzo feldspathic gneiss, with or without graphite (khondalites) and garnet-sillimanite-gneiss. Massive charnockites with granulitic texture, occur as bands and patches. Younger incipient charnockites are also reported from some localities within the basin. Other lithounits noticed in the basin include garnetiferous biotite gneiss and associated migmatites, leptynites, calc-silicate rocks, pegmatites and associated quartz veins. A minor body of dolerite, of younger age (61–144 Ma) is also recorded from a locality of KB. The rocks belonging to Charnockite-Khondalite Group are exposed over about 75 percent of the area of the basin. Scattered exposures of these rocks are mostly confined to the midland and highland zone of the basin surrounded by laterite. Rocks of Tertiary and younger age mostly occupy the low-lying coastal zones as isolated patches encircled by Recent and Subrecent sediments; the latter often found restricted to low-lying portions of the basins forming valley flats and terraces as well as all along the coast (CESS, 1996).

4 Climate

As the basin is on the windward side of the Western Ghats, the rainfall in the region is much more than those areas on the eastern side of the Ghats. The KB benefits mostly from the SW monsoon (locally known as *Edavappathy*) and to a lesser extent from the retreating of SW monsoon(known locally as *Thulavarsham*). SW monsoon breaks over the basin generally by the end of May and accounts for nearly half of the annual rainfall. Generally, June is the month with maximum rainfall. A secondary maximum (related to the NE monsoon) occurs in the month of October. The period from January to March is generally a period of no or little rainfall in the KB. Annual rainfall varies from less than 200 cm to more than 300 cm, the amount steadily increasing from the coastal belt to the interior of the basin towards the Western Ghats. The precipitation from SW monsoon varies from 100 cm to 150 cm while that associated with NE monsoon ranges from 60 cm to 80 cm. The basin receives only 30 cm to 50 cm of precipitation during the remaining post monsoon period i.e., between January and May (Sujith, 2003)

5 Type and extent of weathering

The tropical monsoon climate with clear, alternating and distinct wet and dry seasons, has driven the chemical weathering process to finality by converting upper portions of most of the crystalline rock cover to laterite. All the silicate minerals, with the exception of quartz and durable accessories, have been transformed to kaolinite clay and limonite or hematite. A typical in situ profile of laterite in the KB shows a duricrust (which is amenable to tillage and cultivation), composed of goethite or hematite, followed downward by a clay - enriched zone that overlies partly altered parent rock, showing inherited structures generally in association with a layer of lithomarge. This lithomarge acts as a zone of structural weakness, as it lacks any degree of cohesion with the underlying parent unaltered rock. Also because of its characteristic texture of this lithomargic clay, this acts as a subsurface zone beyond which the downward percolating water, reaching there from upper zones of weathering, is nearly impeded. In other words, this transition zone separating and intervening between more porous upper zone and less porous gneiss (or other crystalline rocks) below, in localities of hill slopes, when exposed to intense precipitation over short periods of time, can act as a zone of rupture or dislocation, allowing the overlying material to quickly dislodge and move downward and outward forming a landslide or a debris slide/slip.

6 Reach and spread of roads

During the past centuries, traffic and trade in the region of Karamana River Basin have been carried on mostly through water ways and partly by means of laden bullocks and hired labourers on land. One of the earliest reference on a public traffic route occurs, in *Unninili Sandesam*, (a literary composition dated 14th century). It mentions an oldtime land route (known as '*kollaperuvazhi*' or '*Thiruvananthapuram–Kollam Nadakkavu*') a portion of which passed through the lowland zone of KB. The present Thiruvananthapuram–Kollam railroad roughly follows the same alignment of this historic land route. Until the first half of the 18th century there were only waterways and open tracks, the latter meant for foot travelers as well as for the members of the upper classes who rode on horseback or in palanquins. The first road, in the modern sense, in this portion of Kerala was constructed in 1751. This was followed by the construction of several others for traffic, passengers and military.

The memoirs of Lieutenants Ward and Conner (1827) covering the period 1816–1820, refers to some of these early tracks/roads traversing the Karamana Basin. During the decade 1862–72 substantial headway was made in road construction in this part of Kerala. One of the major roads traversing the basin from Thiruvananthapuram to Thenmala via Nedumangad was completed in 1876 and that one from Ulloor to Vamanapuram in 1877. The construction of the Main Central Road (M.C Road) to Kottayam was also started during this time and was completed in 1878. A road connecting Vembayam, Nedumangad, Aryanad and further to Shorlacode (Churulode), which runs more or less within the midland zone of the basin and was also opened during this period. The thirties of the last century witnessed rapid extension of road network to the interior of the basin. Roughly a decade before independence, in 1936, there were only five principal roads in the present Thiruvananthapuram District, traversing the basin. These were: (1). M.C Road (249 km,), (2). Thiruvananthapuram–Aramboly Road (86.8 km), (3). Thiruvananthapuram–Shencottah Road (103.37 km), part of which is today's State Highway No.2 and further onwards become part of NH 208 (Kollam–Thirumangalam Road) beyond Thenmala (4). Thiruvananthapuram–Kollam Road-forming part of the present NH 47 (71.19 km) and (5). Nedumangad-Shorlacode Road (62.75 km) i.e. present day Nedumangad–Shorlacode Highway (Sreedhara Menon 1962, pp. 456).

After 1945, a number of new roads for vehicular traffic have been constructed into the interior of the Karamana Basin. It is worth noting that the extension of road network from the urban, municipal and other administrative centres to the interior was largely influenced by factors which may be purely political, social, and economic or a combinations of these, in varying degrees. In most of the instances, these roads are not terrain-friendly, because of lack of scientific planning involving a study on the geomorphic/geotechnical aspects of the terrain along the proposed route for the roads. As a result, a variety of problems emerge either at the time or after the construction or extension of roads during the expansion of traffic network. This is especially true in the case of roads in the higher reaches of midland and highland.

7 Roads and slope stability

Several segments of the road network in the KB, especially in the midland and lower highland steeply cut across or along the toe of the hills, destabilizing such cuts in the event of heavy precipitation. Rain water soaking the regolith leading to higher pore pressures is the obvious triggering mechanism in most of these slides. In fact, there is a strong correlation between the intensity and duration of rain, and land/debris slide events in slopes destabilized by removal of the support at the toe to form a road-right-of-way or by erosion removal of the support along the outer bend of a stream course.

As the debris involved in the slide, passes across the pavement, blocking the normal flow of traffic, it needs to be removed quickly to re-establish the smooth flow

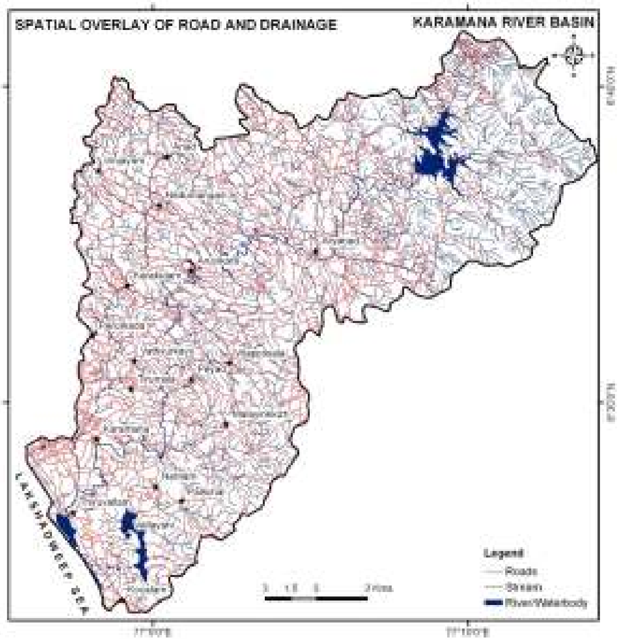

Figure 1. Roads, streams and standing bodies of water (reservoirs and lakes).

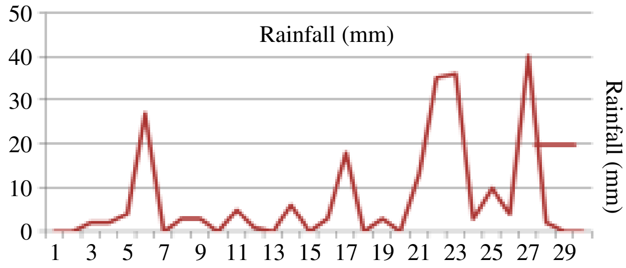

Figure 2. Date on X axis and precipitation (mm) in Y axis: Nov. 2010.

Table 2. Administrative Blocks, Karamana River Basin.

No.	Block Area,	km^2
1	Nedumangad	123.50
2	Vellanad	372.12
3	Thiruvanaanthapuram Rural	43.11
4	Thiruvananthapuram Urban	152.90
5	Kazhakuttam	133.38
6	Athiyannoor	73.73
7	Nemom	134.59
	Total	1033.30

of traffic. In the post slide phase, what remains for documentation and investigation are the rupture surface or plain and a portion of the dislodged material, i.e., soil, weathered rock and the slide plain. In this paper, we discuss the debris slides in some selected locations in the KB that occurred along the arterial roads during November 2010. Figure 1 depicts the present road network within KB and the stream courses of different orders along with lakes.

As noted earlier, the present climate of hot monsoon conditions of the basin, with both high and intense rainfall, has resulted in deep weathering profiles, on slopes that are near the limit of stability. Debris sliding is so common that it can be considered the norm rather than the exception in the landscape of KB. Intense rainfall together with accelerated rate of deforestation and farming of marginal land where population pressures in many parts of the basin are high, causes severe soil erosion almost everywhere in the higher reaches of the basin.

A mechanism of slope failure is the process that causes one component of a slope to move downhill in relation to another. A common misconception is that “the landslide” consists only of the mixture of soil and rock debris that lies in the slide path and on the road. But the debris is only part of a much larger phenomenon, and it is necessary to consider the slope failure as a whole if the slide is to be permanently stabilised. The time factor involved in debris slides is often a neglected. The occurrence of a landslide or debris slide event marks the start of a period of activity that may last at least several years, during which time the *landslide/debris slide grows*. The duration of instability depends upon the rock type and structure, but sliding process eventually diminishes as the slide approaches a stable angle.

8 Precipitation in KB during Nov. 2010

The IMD station nearest to the KB is the Thiruvananthapuram. Table 2 is the rainfall (precipitation) data for Nov. 2010 and cumulative rain fall after Oct. 2010 (source: “The Hindu” weather) is graphed in Figure 2, which shows occurrence of heavy precipitation the 6^{th}, 17^{th}, 21^{st} and 27^{th} of Nov. 2010. Further there is notable correlation between the dates of peaking precipitation and the incidence of the debris slides (Table 3).

9 Description of roadside debris slides of November–December 2010 in Karamana basin

Except the major landslides that occurred in 1992 in the peripheral region of Peppara Reservoir and a lesser ones at Thennur and Peringammala in the same year, no major slides are reported from the basin. However, the indications of past rapid mass movements of varied types are recognizable in several localities along the upper reaches of the basin in the midland and highland zones. The essential features of rapid forms of mass movements recognizable in KB are tabulated in Table 2 (given as Appendix I). It is important to note that all the debris slides contain more than one mechanism of failure. Appendix II lists some of the observed debris slides associated with SW monsoon season during the month of November 2010 in KB (Table 4).

Following is a narration based on the post facto visit to the sites and observational data gathered from each one of the sites.

Table 3. Data on precipitation, Nov. 2010 (Source: *The Hindu* weather report)

Date	Rain fall (mm)	Total rainfall (mm), after Oct., 2010	Date	Rain fall (mm)	Total rainfall, (mm) after Oct., 2010
1	0	413	16	3	468
2	trace	413	17	18	529
3	2	415	18	Trace	519
4	2	417	19	3	523
5	4	421	20	Trace	519
6	27	448	21	13	536
7	trace	448	22	35	572
8	3	451	23	36	608
9	3	454	24	3	611
10	0	454	25	10	620
11	5	458	26	4	624
12	1	459	27	40	664
13	0	459	28	2	666
14	6	465	29	0	666
15	Trace	465	30	trace	666

Table 5. Areas prone to debris slides/landslides (modified after USGS site).

On earlier landslides.
On or at the base of slopes.
In or at the base of minor streams.
Along the base or top of a land fill slope.
At the base or top of a steep cut.
On built hillsides with leach field septic systems.

10 Description of slides

10.0.1 Location A. Vanchuvam, Chullimanoor:

On 21-11-2010, at about 6.30 P.M, people in the neighborhood of the slide heard a loud thunderous sound caused by this enormous debris slide at Vanchuvam, about 5 km from Nedumangad along the Thiruvananthapuram–Shencottah state Highway. Debris containing top soil, standing vegetation and small and large boulders of laterite measured in decimeters to couple of meters or occasionally even higher, weighing 1500 to 2000 tons instantaneously broke off the slope along a gash of 30.0 m and slipped downward leaving a free face of $\tilde{3}0.0$ m length. The tongue of debris crossed the paved road blocking the road traffic, while its distal end jumped into a lower order stream of the adjacent Killi Ar basin. Regular traffic stood blocked for 24 hours.

The vegetation of the affected hill is mostly four yr old rubber trees and other mixed trees along the perimeter. Though the water laden displaced mass is dominated by laterite, it lacked boulders of very large dimensions. The slip blocked the traffic for about 24 hours and the debris covered the road pavement while the distal end of the tongue jumped into a 3^{nd} order stream - a tributary of Killi ar. (a major tributary of Karamana River).

A zone of gray to white kaolinitic clay, one of the outcomes of chemical weathering of khondalites, was noted 16.0 m above the road pavement in the scar left by the rupture surface of the debris slide. A small perennial pond (dia.=$\tilde{5}$.6 m), that occurred in the path of debris flow was overwhelmed and completely covered by debris. Reportedly, people in the neigbourhood heard a loud and thunderous noise that accompanied the instantaneous outward and downward sliding of debris down the slope toward the road pavement. The perennial pond perhaps suggests the abundance of groundwater filling the pore space in the regolith. The contour-styled-platforms sloping uphill and separating the rows of rubber plants would have affected a higher volume of charging of the subsoil with rainwater trapped in the platforms, leading to an increase in the pore pressure and decrease in the shear resistance. Apparently the heavy rain fall prior to the date of slide, the landscaping in the rubber plantation, the macro-structures like joints and fractures dipping toward the road pavement and the nearly vertical cut to form the right of way of the segment of the road steep jointly triggered the mass movement of the debris to slide headed to the pavement and the lower order stream along the other edge of the road pavement.

The top soil has a thickness of 1.6 m and underneath it is 10 m laterite. We can also see clay enriched laterite having 16m thickness from the ground surface or roads white in colour, promoting the land slip process. Below it, we can see loose laterite debris of 3.6 m, below it, land laterite of thickness of 12 m from the roads.

11 Location No B. Near the entrance of Keltron, Karakulam:

A debris slide occurred near Keltron entrance on 6.11.2010 Friday at about 9.30 am (Figure 3). The slide affected the Thiruvananthapuram–Shencotta Road near the main entrance to the Keltron establishment (12.8 km from Thiruvananthapuram) at 8°62′31′N 76° 99′86′′E. The site contains thick growth of shrubs and

Table 6. Areas relatively safe of debris slides/landslides (modified afterUSGS site).

On hard, non-jointed bedrock unaffected in the past.
On relatively flat areas away/free from changes in slope angle.
At the top or along the nose of ridges.

Figure 3. Debris slide at Vanchuvam.

small trees (Figure 3).Top soil of about 1.50m thickness, under a thin blanket of colluviums, is seen on the area. Many trees were uprooted during the process of debris slide. The roots of trees, found exposed, were growing towards down slope direction. The total amount of material involved in the slide is about 10 tons and consisted of a mixture of colluviums, soil, laterite, lithomarge and some partly decomposed boulders of khondalite.

12 Discussion and summary

In India GSI has identified a large region as prone to landslide/debris slide which covers approximately an area of 0.392 million km^2, spread across 20 states (i.e., parts of Himalaya, Nilgiri, Ranchi Plateau and Eastern & Western Ghats). Among these, Sikkim and Mizoram fall under very high to severe hazard range. Many districts in the States of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland and Manipur come under high to very high hazard range. The hill tracts in the states of Karnataka, AP, TN, Maharashtra, Goa, MP and Kerala are grouped under low to moderate hazard-prone zones. Table 5 depicts the areas subject to repeated rapid scale mass wasting events. While planning for developmental activities like establishing townships, road/rail road alignments and similar other investments, such sites needs to be avoided or shall be undertaken only after implementing appropriate preventive measures. Further, if large tracts of land of the categories listed in Table 6 are handy, tracts with a history of land/debris slides may be avoided to align communication routes.

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Risk assessment, avoidance and control during the planning, construction and stewardship phases for the dam projects in Kerala

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ABSTRACT

The issues and controversies on the instability of the Mullaperiyar dam and associated geo political standoffs have aroused public and scholarly concerns over the stability of existing and future dams in Kerala. Dams were regarded as 'temples of modern India' by earlier planners. Due to proliferation of the dam projects, development dwindled down to a diminishing level of return and then these temples were ridiculed as 'tombs' of modern India. Now the instability factors of the dams too are themes of debates called 'dam dooms'. Older dams world over too have the inherent flows like the absence of any projections of their impact, structural strength or risk while they were conceived, executed and maintained. But in developed countries later investigations and regulations brought the whole life cycle processes under strict surveillance and control. The processes of risk assessment, avoidance, control or mitigation for dams in the state become an uphill task due to the conflicts in stake holdings interests all along. Factors for the risks can be natural, physical or social. Social group include territorial, corporate, ethnic, cultural, socio- linguistic and fiscal alignments. Concerns like projects located outside the territory or jurisdiction of the owners, owners or stakeholders living away from the risk zone but enjoying the fruits of the dam as in the case of irrigation or hydropower, conflict in interests between upstream and downstream entities, geopolitical stake holdings of cultures and groups etc. throw challenge and subsequently impede on the safety surveillance and stewardship of the dams. The general laxity in safety matters prevalent in developing countries is evident in these cases too. A causal perusal into the geomorphic and geological framework of the project site will reveal that most of the current projects are located in a row along a shear, fracture or lineament zone which defines the mid rib of river valley systems. Most of the hydroelectric projects are located in the vicinity of the fault zone across the river system manifested as distinct water fall or cascade. These are all structurally and or seismically vulnerable areas. Most of the river systems carry multiple run of river projects for efficient hydroelectric power generation. All these indicate risks and hazards. 'Disasters occur when hazards meet vulnerability.' Land cover and land use in the upstream side of the dam is constantly changing by process of deforestations, large scale farming and terrain modification with indiscriminate soil erosion or excavation. Meteorological deviations due to processes ranging from global warming to deforestation were beyond forecast while the existing dams were designed and executed.

Most of the globally documented modes of failure like Structural failure, Differential settlement, High uplift pressures, Settlement and cracking of concrete or embankment dams, Piping and seepage, Seepage and erosion along hydraulic structures such as outlets, Cracks in dam etc can be avoided by proper geological and environmental scrutiny. A comprehensive sociological and demographical mapping will help in assessing the risk and vulnerable situations. From the experience gained by the Impact assessment in several dams in Kerala the authors propose a protocol for the identification of the risks and vulnerability for the globally accepted risk factors and the stewardship practices to be followed in different life cycles of the dam projects.

1 Introduction

There is no scarcity for debates on dams and projects on Kerala. The learned resentment towards the impoundment of water started with planning of Thaneermukkam barrage in Alapuzaha District in 1968. The public environmental awareness rolled up to resentment in 1973 when the policy makers and public aligned in diametric poles on the aptness on the construction of a power project in Silent valley. Since then every single project is reeling under controversies of all kinds other than dam safety. Since no major dams were constructed in last few decades there were no debates on the dam safety until the bilateral dam safety issue was brought up by the stake holding states of Kerala and Tamil Nadu on Mullaperiar dam and when Moolathara dam in Chittur in Palakkad broken in November 2009 (The Hindu, 2009) Moolathara dam was a part of the Parambikulam Aliyar system a share stake hold arrangement between Tamil Nadu and Kerala The Mullaperiyar dam is a living example of stake holder conflict between the states. While the issue has attracted the attention of the technology and the politics in a national level, debates on the safety of the dams are now all over the state. One will have to admit that the archaic mode of construction without any impact analysis and its location in the densely populated area will keep the Mullaperiyar dam (Mathew Roy 2000) in a red alert list for sure. The Edamalyar case which has attracted the national attention too was triggered by the structural risk factors attributed to the dam and associated structures (The Hindu 2011).

A hazard by definition is a threat of a naturally occurring event that will have a negative effect on people or the environment. Many natural hazards are interrelated each other such as earthquakes can cause tsunamis or drought can lead directly to famine. A natural disaster is the outcome of a natural hazard. It leads to socio-economical and environmental losses. The resulting loss depends on the vulnerability of the affected domain to resist the hazard. It is well known that '*disasters occur when hazards meet vulnerability*' Hence a hazard will never result in a disaster in areas or situations without any vulnerability. So bringing all predicable vulnerable elements to zero should be the objective in Safety Management of the dams. Emergency management of dams is the response unit dealing with and avoiding risks. It involves preparing for disaster before it occurs and supporting, and rebuilding society after the disasters. In general, it is the continuous process by which all individuals, groups, and communities manage hazards in an effort to avoid or ameliorate the impact of disasters resulting from the hazards. Actions taken depend on perception of risk of those exposed. Dam failures cause flooding drastically different from natural flooding. A flood from a dam failure may arrive before any warning or evacuation can take place. The failure of large dams results in flooding with enough energy to damage or destroy residences and other structures (Graham W.J, 2009). Both natural and anthropogenic causes play major roles behind failure of dams. Failure Modes Identification (FMI, Table 1) is an early step in a risk assessment and should be standard practice for traditional standards-based approaches to dam safety evaluation and design. Most of the causes are either direct or indirect result of the improper assessment of the system study at the site or its environs. Development of an investigation procedure at the preliminary and operational stages can reduce the risk factors.

The geomorphic, geological, hydrological investigations now in place focus only on the construction feasibility. Investigation with a view of safer future has to include models of change of these factors. Current practices of soil erosion and drainage pattern studies too do not foresee the changes. They are to be replaced with proper modelling. Land use model has to depict changes from the day of commission of dams onwards. The FRL of the reservoir mark datum levels or base flow levels for the streams in the upstream side of the dam once the reservoir is full. These levels are different from the predam level of confluence points. (Babu G L *et al.*2007). Studies by the authors for existing dams and their environs have shown that there are distinct changes in the geomorphic, drainage and soil erosion parameters in the upstream and catchment areas of the river systems before and after construction of dams (FEMA 2001). Meteorological deviations seen in the last decades too have made their dent on the physical systems. When the spotlight of importance is only around the sustainability of fauna, flora and inhabitants, the inherent or induced structural sustainability of the very dam is pushed to back benches.

Table 1. Common Failure modes of dams and their causes.

Failure Modes	Causes
Overtopping	Inadequate spillway design
Debris blockage of spillway	Settlement of dam crest
Structural failure	Foundation defects
Differential settlement	Sliding and slope instability
High uplift pressures	Uncontrolled foundation seepage
Settlement and cracking of concrete or embankment dams.	Piping and internal erosion of soil in embankment dams
Piping and seepage	Geological instability
Seepage and erosion along hydraulic structures such as outlet	Conduits or spillways, or leakage through animal burrows
Cracks in dam	Excess rainfall
Piping of embankment material into conduit through joints or cracks	Inadequate maintenance and upkeep.
Deliberate acts of sabotage.	Poor surveying
Design error	Equipment malfunction
Sabotage	Any other

2 Safety elements of a dam

The safety of a dam has to be assessed based on an integral safety concept, which includes the following elements (Wieland, 2009): Structural safety (elements like: geologic, hydraulic and seismic design factors and design criteria). Safety monitoring (elements like: dam instrumentation, periodic safety assessments by dam experts, etc.). Operational safety (elements like: reliable norms for reservoir operation under normal and extraordinary –hydrological-conditions, training of personnel, dam maintenance, sediment flushing, engineering back-up etc.). Emergency planning (elements like: emergency action plans, water alarm systems, evacuation plans, engineering back-up etc.). A quick look into the causative factors that develops into a catastrophe (Table 1) will reveal many areas of risks in the geologic, hydrologic and seismic factors. (Srivastava and Babu, 2010)

3 Risk factors

Identification of the Failure modes is the first stage of Risk Assessments. The current paper deals only with risk factors that occur in nature around dams and areas where the risk can originate now or at any time in future.

Risks that are evident at the time of planning or constructions can either be avoided or treated. But when the risk factors are developing later the dam is said to be in a process of aging. Risks are on 'progressive elaboration' in their roles and intensity. Identification of these risks might not be easy in the starting phase. By the time they are traceable they might have turned to a threat level (McDonald, L.A. and C.F. Wan. 1998). Identification and mitigation come within the role and responsibilities of the risk management team. (CEATI international, 2010)

4 Structural safety factors degrading with age

A dam structure which was safe at the time of construction will not maintain the same structural integrity even if the same conditions prevail around. A life span of a dam is defined as period as long as the dam is in a safe mode. No prediction of this span is fool proof. Slow and evolutionary factors of weakness set in over a period of time. These are especially true in case of dams constructed during yester decades. Varied technologies of constructions prevalent time to time were not tested for their longevity or ability to withstand the strains of chemical or weathering degradations. Again Mullaperiyar is the best example where the construction material is largely bound by lime and the pH factors of water trend to acidic due to the changing farm practices or industrial discharges.

4.1 Geological factors

While designing a dam safety factors like the dam break analyses on construction elements are in place, but not much of thought are given to the geological or geotechnical factors on their long term risk factors. Geological features are assessed now for their structural, hardness, porous and permeability, stress and strain factors. Most of the lineaments do have alkaline or carbonate intrusives along them which are susceptible for cave formation, dissolution and leaching. It is highly essential that lithological and structural mapping in surface and subsurface levels are to be carried out before choosing the dam axis or location. Inundation area also has to be surveyed in detail for their tectonic, structural, petrological and weathering aspects. The safety concerns to be taken to consideration while planning a dam are chemical processes like swelling due to alkali aggregate reactivity, sulphate attack, leaching etc. that can occur within the lithological units over a period of time. Periodic review of such chemical process has to be done for the rock and the dam structure. In temperate climatic conditions weathering, leaching and latertizations are the processes happening on the rock surfaces including the basement. Seepage of water or water with clay into the fracture planes or major joints release the friction of these plains to trigger post monsoonal tremors in the lineament zones.

4.2 Geomorphic factors

During the design and alignment phases, geomorphic aspects considered to model are limited to the reservoir and the catchment area as of now. The current authors have documented considerable variations the slope and drainage configuration of the catchment areas before and after the construction of the dams in many dam projects of Kerala. Similarly there are noticeable changes in the soil erosion in the catchment areas before and after construction of dams (Sujin and Chacko 2005-1). These inferences lead to the possibility of non linear soil erosion, drainage development and seepage changes in the catchment areas. Conversion of upland forest and prairie vegetation to agricultural land uses, leading to an accelerated runoff and impaired soil erosion that subsequently transform the terrain to channels, floodplains, and wetlands have been reported from other dam areas as well (Fitzpatrick *et al.*, 2009). Since these are weather induced processes change in the duration and rate of precipitation can lead into geotechnical surface processes ranging from aggravated soil erosion and mud slips to landslides (Sujin, J. and Chacko 2005-2). While an inundation area is planned for weather cycles of drying and wetting and variation in temperature from cold to warm have to be taken in to account as these fluctuating features will induce in fissures in the rock bed. Seepage in the foundation and the dam body can be set in by processes like dissolution of material, weakening of conglomerate etc (Foster, M., and Fell, R. 2002)

4.3 Seismic factors

Seismic activities are one of the major risks on dams as on any other massive man made structure on the face of globe. But there is a basic difference between the load bearing behaviour of buildings and bridges and that of dams. While the buildings and bridges have to carry mainly vertical loads due to the dead load of the structures, on dams the main load is the water load, acts in the horizontal direction. In the case of embankment dams the water load acts normal to the impervious core or the surface facing upstream. Earthquake damage to buildings and bridges are mainly due to the vertical shake component. Concrete and embankment dams are much better suited to carry horizontal loads than buildings and bridges (ICOLD, 2010) One of the ways to express the severity of the earthquakes is to calculate the return period in years. Larger the count worse is the damage. Large dams are designed to withstand an earthquake with a return period of about 10, 000 years, whereas buildings and bridges are usually designed for an earthquake with a return period of 475 years. In order to prevent the uncontrolled rapid release of water from the reservoir of a storage dam during a strong earthquake, the dam must be able to withstand it. The maximum strength of the earthquake that can be withstood by the dam is referred to as the Safety Evaluation Earthquake (SEE) or the Maximum Credible Earthquake (MCE) (ICOLD, 2010). Although the design criteria and analyses concepts used in the design of dams built before the 1990s are considered as obsolete today, the reassessment of the earthquake safety of conservatively designed dams show that in general these dams comply with today's design and performance criteria are safer. In many parts of the world the earthquake safety of existing dams is reassessed based on recommendations and guidelines documented in bulletins of the ICOLD (200) In a tectonic frame work like south India, the river systems are associated with lineaments which are seismically sensitive and have deep seated fault or joint systems which are or shall turn to be conduits triggering in the 'piping' and later dam breaks (Water portal India, 2011). There are two main systems that decide the very location of the dam. (1) The lineament system running at an angle to the mountains which drain into the river from both sides and (2) multiple step faults which provide potential level difference to the run of river systems where the consecutive dams are exploited repeatedly for generation of power. These deep seated step fault planes are possible sources of reactivation. Fractures parallel to the main trend of the river are very deep and they transmit tremors even from remote epicenters. Seismic episodes during or after the main monsoon period are common features these years in river systems of Bharathapuzha, Pamba and Achankoil lineaments. Development of a reservoir can trigger a reservoir generated seismic event called Reservoir Induced Seismicity (RIS). Possibilities of such events can be the maximum when the reservoir is full and the fracture system has least friction due to water seepage in to the structural planes. Risk factors are exponential when terrain is loaded with proximal reservoirs and when all of them are filled to the brim. Cracking can be caused due to seismic actions or non-uniform foundation movements etc. (Froehlich et al. 2008) Frequencies of the local and global incidents of seismic episodes are increasing in the state. Haiti (Wikipedia. 2010-3) and 2011 January Pakistan tremor which shook a large belt from Dubai to New Delhi and are remind us callous power of destruction.

4.4 Hydrological factors

Apart from the geotechnical factors hydro geochemical factors also can determine the longevity of the dam and the reservoir bed. The surface water drained into the reservoir too are progressively changing its pH and corrosion factors due to the change in farm procedures in the catchment zone like introduction of artificial fertilizers and pesticides. Discharges from the industrial production units too have changed the composition of surface water to a greater extend. Meteorological conditions are changing locally and globally. Recent landmarks of devastations due to flood took the meteorologists to surprises during 2010 massive floods in Pakistan (Wikipedia 2010 (2)) and 2011 floods in Brazil (Yahoo news 2011).

5 Risk assessment and risk management

5.1 Risk defined

Risk, its assessment and management in the case of dam failures are defined and dealt differently by different agencies and authors. It is a measure of the likelihood and severity of adverse consequences if a dam breaks ICOLC (2000) definitions are adopted in this paper for describing process and procedures in assessment and management (see section 5.3) The risk factors discussed here are limited to geological, hydrological and meteorological genre. ICOLD (2000) defines Risk as the mathematical expectation of the consequences of an adverse event occurring (i.e. the product of the probability of occurrence and the consequence) or alternatively, by the triplet of scenario, probability of occurrence and the consequence. Risk Identification is defined as the process of determining what can go wrong, why and how Standard procedures of alleviation of risk factors approved by ICOLD (2000) are discussed in Section 5.2. A more detailed mode of approach is defining the dam safety operations are classified in to application areas like:

Failure Modes Identification Approaches (Qualitative Approaches)

Index Prioritization Approaches

Portfolio Risk Assessment Approaches

Detailed Quantitative Risk Assessment Approaches

While alleviation of risk is process for an individual dam by a team working on the safety and construction departments to characterise risk and propose methods of avoidance or mitigation, the application approach is dealt by more specialised teams dedicated to the trade. These teams are responsible for a detailed quantitative modelling of the risks with risk indices and portfolio risk benchmarking (Section 5.4 to 5.7) of a group of dams in an area, basin or of a type.

5.2 Alleviation of risk factors

No dam can ever be conceived as risk free. An ethical and professional wisdom by the planners, executors and operators alone can make the process safer and sustaining. Risk alleviation is an iterative process in the life cycles of the dams. Figure 2 gives the process flow for alleviation of Risks and Hazards for planning to operational phases. Most of the existing dams had higher and popular priorities other than risk assessment when they were built And 'anticipatory, participatory environmental management processes' were not even heard of at those times. But the current projects on the drawing boards have played with alternate options before settling to the favoured ones and anticipatory, participatory environmental management processes are in place in India (Govinda R 1999)

Figure 1 represents progressive elaboration of the risk alleviation process where different risk reduction modes are applied during the progression of the project. Figure 2 shows different risk alleviation management

Figure 1. Risk treatment thought the life cycle of a dam.

components and sequence in place Avoidance, Prevention, Mitigation etc. are experimented throughout the phases in order to design out the risks. If construction and operation can be done with higher safety and efficiency factors by another owner or organization transferring the project too can be option before deciding to go ahead with Residual Risks. Depending on the risk factors insurance can be introduced for compensating in the event of a disasters. By following these steps the retained risk matrix turns fewer and feebler. The process will start right from the proposal level, When proposals to base plan is considered with due weight to risk factors. Similarly when a change in the pattern or construction method is opted on any ground, risk avoidance will be taken as the prime concern. Examples of prevention are landslides, aggravated soil erosion These can be alleviated by preventive or avoidance measures. Another simple example of mitigation is cement grouting of open fissures in indentation area, dam site or outlet areas (FEMA, 2002)

5.3 Functional hierarchy of the risk, assessment, alleviation and management components

The Functional hierarchy of the risk alleviation, assessment and management Components (Figure 2) are:

Failure Mode Identification (FMI): is a procedure by which potential failure modes in a dam system are identified. Risk Assessment process starts with (FMI). It is a qualitative approach at Risk Characterization Level. Though not a decision tool FMI is standard traditional practice for traditional dam safety evaluation and design process (Association of State Dam Safety Officials, Federal Emergency Management Agency, 2001) and generate a focus on the issues to be studied. Standard FMs and their causes listed in Table 1. FMI will suggest possible natural or human oversight in site selection or construction approach or execution can lead to heavy consequences. Risk Estimation is the process of quantifying the probability and consequences components of risk. This first level of quantitative risk estimation will principally quantify the probability and consequences components of risk. This is again a step in detailed quantitative risk assessment approach. Risk Analysis is the use of available information to estimate the risk from hazards to individuals or populations, property or the environment. Here the analysis done on inputs from Risk Estimate step to find the extend of risk. This phase generally contain the following steps: Scope definition, Hazard identification, and Risk Analysis. Risk Evaluation is the process of examining and judging the significance of risk. This phase goes concurrent to Risk Analysis This is a step in detailed quantitative risk assessment approach also. Risk Assessment is the processes of deciding whether existing risks are tolerable and present risk control measures are adequate and if not, whether alternative risk control measures are warranted or justified. Risk assessment incorporates information from the risk analysis and risk evaluation phases. Risk Management is the systematic application of management policies, procedures and practices to the tasks of identifying, analyzing, assessing, treating and monitoring risk. Risk Control is the implementation and enforcement of actions to control risk, and the periodic re-evaluation of the effectiveness of these actions. Avoidance, prevention and Mitigation are steps to design out risks and Risk finance to contain the loss (Figure 1) Reassessment: Process iteration after each risk control measures are introduced or within specific intervals

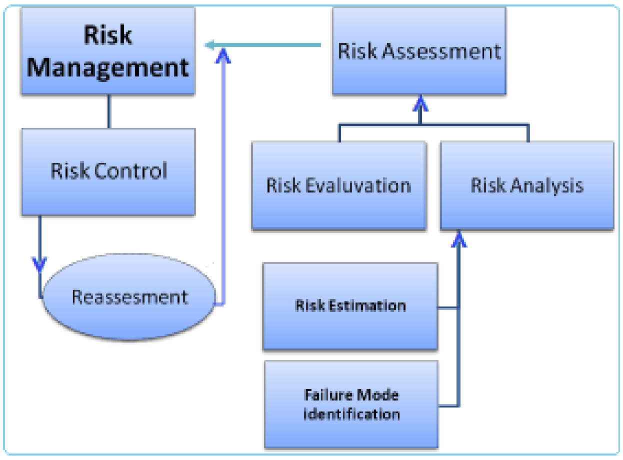

Figure 2. Functional hierarchy of the risk alleviation, assessment and management Components.

5.4 Failure modes identification (FMI) approaches

In FMI approach potential failure modes are identified for each dam. A failure mode is a sequence of system response events, triggered by an initiating event, which could culminate in dam failure. A broad interdisciplinary team of dam engineers, who have knowledge of historical dam failure mechanisms, would develop a list of failure modes is the basic approach. FMI provides a more comprehensive safety evaluation of a dam and a basis for strengthening many aspects of a dam safety (e.g. instrumented and visual monitoring, emergency preparedness planning, O&M, etc.). The FMI output range from a simple list of failure modes, to a report listing of associated effects, consequences, compensating factors, and risk reduction measures. FMI efforts are simple; but it has a wider acceptability as a traditional approach and integrates the total safety program. It contributes to the quality assurance, communication of risks, identification of risk reduction measures, and prioritization of issues. However, when compared with other approaches the area of uncertainty is wider and subjectivity of the team will be more. Failure Modes Identification is a qualitative approach and not a decision tool and is confined to the first level (Figure 2).

5.5 Portfolio risk assessment (PRA) approaches

Unlike FMI, Portfolio risk assessment (PRA) is a risk reduction program to study of a group of dams. PRA is an efficient process involving the reconnaissance level application of the identification, estimation, and evaluation steps of dam safety risk assessment to a group of existing dams and suggesting risk reduction measures. The products include an engineering standards assessment and risk profile for the existing dams, and a basis for developing and cost-effectively prioritizing risk reduction measures and supporting investigations. PRA risk metric can be used to strengthen the owner's monitoring and surveillance program, and to provide inputs to various business processes, such as capital budgeting, legal evaluations, loss financing, and contingency planning. PRA is a valuable and increasingly accepted approach for cost effectively prioritizing dam safety remedial measures and further investigations for a group of dams. It provides insights that can better inform owners about the business and liability implications of dam ownership. PRA outcomes are not in-depth final risk analysis must be used with regard for the limitations of the approach and should be periodically updated (Wieland 2009)

5.6 Index prioritization (IP) approaches

An index prioritization approach is a means of quickly ranking dams for addressing dam safety issues. The ranking is based on an index, calculated from a combination of weights, which are assigned to capture various attributes of identified dam safety deficiencies. The attributes and ranking procedures are usually prescribed in order to form a common basis for ranking between dams. These approaches are best used as an initial screening of a portfolio of dams, or a comparison to other forms of risk analysis. IP approaches are a valuable and increasingly utilized approach for prioritizing dam safety issues and investigations, but should be calibrated and must incorporate a risk metric to be considered risk-based. They are generally less costly to use than PRA, but are more limited in the scope of their outcomes with no in-depth risk analysis

5.7 Detailed quantitative risk assessment (QRA) approaches

A detailed quantitative risk assessment (QRA) is a valuable approach as a decision tool and comprises the steps of risk identification, estimation, and evaluation discussed in section 5.3. The purpose of performing a detailed QRA is typically to provide insights into the adequacy of an existing dam, or to provide justification for risk reduction measures. Detailed QRA approaches have in depth supporting analyses and are valuable for providing insights and understanding of failure modes and associated risks for stakeholders.

6 Dam safety and risk assessment in India

Dam safety procedures and protocols were not well developed in India as in the developed countries when 84% of the 4291 major dams of the country were constructed (Wikipedia 2010-2). Some information on the Geology and the riverbed rock properties were alone available while the dams were constructed. Even the basic hydrographs were not available for the design or projection of the flood. World Commission of Dams feels that inadequate hydrological data also can cause dam failures (Jauhari, 1999). The very concept of integrating Geology, Geomorphology, Hydro geology and Hydrology did not exist at the time of construction of the 84% of the existing dams. This leads to the conclusions that all major existing dams are to be reassessed for their safety through modern approaches and standards (Government of India, 2010). By introducing a report on Dam Safety Procedures, Dam Safety Organisation of Central water Commission under the Ministry Of Water Resources in 1986 India too started to pay attention to the world trend of dam safety. Later in 2010 Government of India (2010) presented Dam Safety bill in Parliament and created a National Committee for Dam Safety. The committee will be the apex level organization overseeing the dam safety in general and act as the repository of technical documentations concerning hydrology, dam foundation, structural engineering of dam, and watersheds upstream of dam. All new specified dams shall be investigated, designed and constructed only by the organizations empowered to do so. New regulation is in the process of implementation

7 Dam safety and risk assessment in Kerala

As per World Commission of Dams (WCD) Kerala has 54 dams (January, 1999) and only recently a state Dam Safety Authority has come to existence (Government of Kerala, 2011). Most of the dams in Kerala were built when the adversities of the dams or the risk factors were little known to the planners and builders. Located in densely populated areas their risk factors are huge. Not much of the data bases are available for the monitoring of the systems around these dams. There are ownership issues for smaller dams and barrages. But most of the bigger dams are government owned and controlled by Irrigation, Tourism and Electricity departments. At the same time many dams in the lower order streams have legal jurisdiction, ownership and operation issues with neighboring states. When the farming lost its importance in the state irrigation dams lost their status of being 'temples'. Water flowing through many dams is under stake holder conflict as they are governed by bilateral or trilateral pacts between states. All these factors individually and collectively contributed for taking the safety policy priorities away from the dams in the state (Government of Kerala, 2011).

The authors are of opinion that none of the 54 dams do not keep up the safety standards of ICOLD (2000) or any standards globally accepted. There are many dams in different phases of the planning and approval. Although Dam break analyses are done for them individually no detailed or integrated approaches of regional or portfolio safety analyses have been done. The Risk characterizations do not follow any global norms or standards. Now that Dam Safety Authority is in place and the breaking of Moolathara dam and the controversy raked up the standoff between the state governments on the safety of the Mullaperiyar dam have added a new dimension to dam safety awareness. Most of the rivers in the state have narrower valleys especially in the younger order of streams. So the distance between the dams of two adjoining river systems are smaller and the impact on one will influence the other. This leads to Portfolio Risk Analyses (PRA) in intra-basin and inter-basin dimensions. Deep seated fractures are interconnected and the transmission of seismic waves across the valleys are common feature which adds significance to the inter basin PRA studies. Issues of inter basin water transfer also justify such studies. Majority of the dams are for power generations and in order to exploit the potential level differences they are located on the up throw side of the step faults and are susceptible for tectonically triggered or RIS tremors. Though KSEB is monitoring the seismic activities from all major dam sites not much of studies are carried out on these waves. In other words it is now almost impossible to know response of the individual dams to the seismic waves as Safety Evaluation Earthquake (SEE) or the Maximum Credible Earthquake (MCE). Detailed Geological and Structural maps are available only for the dam sites and other construction areas. Details of the Inundation and Catchment areas are not documented for the purpose of dam construction except for the regional maps of Geological survey of India Hydrographs are not maintained or monitored majority of the cases.

7.1 Dam safety authority (DSA)

By the constitution of a Dam Safety Authority (DSA) be a positive shift in the matters of Dam safety is envisaged. Operations of DSA can be under three management functions:

Risk Assessment of the existing and Dams
Control of Risks and management of Dam safety
Stewardship of dam safety

DSA should be in total command of the safety matters of all dams within the state irrespective of the ownership, operatorship or any other stake holding of individual dams. Diligent Risk Assessment Protocols have to be drawn separately for the existing and proposed dams by pooling the collective wisdom and expertise from all players in the field including researchers and academics. In order to prioritise the Risk Alleviation a Rapid Risk Assessment can be done for the existing dams. A general check list of the controls to be imposed and periodic stewardship reports are to be prepared along with site specific attention for individual dams.

7.1.1 Risk assessment (RA) of existing dams of the state

The authors are of the opinion that Risk Assessments of individual dams are to be carried out for all the existing dams in the state. The methodology adopted by ICOLD (2000) or their modifications and derivatives with proper normalization for the tropical terrain can be bench marked and standards can be adopted as Dam Safety Regulation of the state. Smaller dams like check dams also should be brought under these regulations. Steps like FMI, Risk estimation, Risk Analysis, Risk Evaluation, Risk Estimation form the part of RA. The risk thus documented for the existing dams are to be mitigated on issue based priority. These operations can be completed on a project basis.

7.1.2 Control of risks and management of dam safety

This has to be an ongoing program of the DSA. Many activities in the upstream and catchment side or in the vicinity of the dam can cause instabilities to the dams. Similarly there can be natural disasters which can impair the life or health of a dam. DSA can draft scheme for avoidance of these impacts or can take action in mitigating the impacts including fall safe steps. DSA should be empowered to take legal action on that breach the Safety regulations.

7.2 Risk assessment and management routine

A Risk Assessment and Management routine has to make mandatory for the following activities

7.2.1 Activities in the catchment area

The commissioning of dams leaves behind Roads, Buildings, bridges and communication channels like phone lines that were in use during construction phase in the upstream side. Most of them turn to be essential for the maintenance and security purposes. Though the initial plans were to demolish them and protect the environment, in most case they turn out be arteries of development. Though one cannot defend these actions these are physical truth in a developing country. Activities like road making, deforestation, farming, rock mining, terrain modification, tilling the ground etc can change the processes like soil erosion, surface water runoff, infiltration and result in changed hydrographs and accelerated soil erosion. Any such activities in the catchment can have impact on the dam. It should be made imperative that clearance may be obtained from Dam Safety Authority and Environmental Impact Assessment have to be done for all major developmental activities. If industrial units are functioning in the upstream side discharges are to be chemically examined for their pH and corrosiveness on concrete, alkaline earth, limestone banks. Detonators are not to be allowed in the mines in the proximity of dams.

7.2.2 Activities in reservoir are

The major activity that is likely to occur in reservoir area is the massive sand dredging. The state Government is running pilot dredging activities in Aruvikara in Thiruvanthapuram district. Once proved successful the process is supposed to be advanced to other river systems. Already there are sand scooping in most of high order streams and rivers. The dredging activities are to be limited to the land configuration existed before the construction of the dams such that base line of erosion does not change due to dredging. Such dredging will generate an accelerated subsurface water flow into the reservoir by passing the hydrograph of flows. All such dredging operations are to be preceded with Rapid Environmental Impact Assessment and Geotechnical clearance.

7.2.3 Natural disasters

Natural disasters other than the earthquake that can impair the dam safety are floods, landslides and mud creeps. All these eventualities can be forecasted and possible steps can be taken to avoid or reduce the risks

7.3 Dam safety control centre (DSCC)

Dam Safety Control is a complex operation demanding high level expertise and quick response. For reasons of convenience and cost effectiveness a well connected central hub of operations under DSA is recommended. There may be trained operational staff under each owner or operator of the dam who will act as per instructions from DSA. DSCC will monitor all operations and developments in the dam and catchment areas. A dam watch cell working 24/7 will be able monitor weather, water level etc through remote cameras. Data from the seismographs, rain gauges and flow measurements has to be updated.

7.3.1 Data repository

DSA can generate a data repository which other stake holders of dams or public agencies can take advantage of. The DSCC should have following information on each dam for cyclic reassessment of safety and must be available to the authorised users without any hurdles
Historical information (Standards):

Remote sensing images showing geology and geomorphology for different periods

Remote sensing images showing forest, land cover and environmental details

Topographic and land use maps published at different times

Detailed listing of the seismological events of minor or micro levels

Meteorological data base on temperature, wind, rain, storms and floods

Regional hydrological parameter

Current detailed information (Static):

Lithological map showing weathering and cross sections

Soil map, soil moisture map

Structural map

Contour maps, river cross sections
Subsurface information obtained by drilling
Geophysical map showing seepage characters
Physical properties of rock, weathered rocks and soils

Current detailed information (Dynamic)
River water level
Hydrographs and stream flows
Ground water level
Soil erosion
Sediment transport and deposition
Seismological data
Meteorological data

Risk Assessment Reports
Risk Assessment Reports of levels
Emergency Action plans and Recommended Emergency responses

8 Stewardship of dam safety

The current concept of safety is security driven. The up keeping staffs are mostly security personnel and a few technical staff with only preliminary skills for monitoring water levels or gauging the flows or rainfall. Hydrographs are not prepared for the inflows nor out flows are monitored expect as the production figures in hydroelectric power plants. Once the DSA is place there should be change in the Stewardship policies and processes. Primarily, the stewardship of Dam safety should not be confined to any single dam owner or operator. The processes include the Risk Assessment are to be carried by skilled technical people. Dam Safety Control is put to work by Management and Surveillance teams at each Dam site and overseen from the DSCC. There will be enforcement teams for preventing the violations.

A coordination team will be able to coordinate activities across the total profile of government, society and DSA organization. Stewardship team has to have communication with the society and symbiotic coordination with other operational agencies in the dam areas. Residents all along the brim of the reservoir use these water bodies for fishing, transportation and their water needs. They are to be informed about the Dam safety. The operations of DSA are to be visible to the public through a web site and public should have access to system through devices like toll free phones etc.

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School safety-steps for developing the culture of safety

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ABSTRACT

Hyogo Framework for Action (HFA), under its one of the priority is trying to build a culture of safety and resilience at all levels. For making a community resilient to disaster HFA recognizes the vital role of school. Schools are used as the shelter, globally. But there are very little initiatives for making the school safe. Moreover, the students are main firewood for rolling the country to forward. If they are prepared a culture of safety would be developed throughout the nation. Considering all the factors the importance of working with school is emerging day by day. In 1997, Ministry of Education has taken some policy decision to disaster preparedness at educational institutions. After the devastating flood of 2004, Government of Bangladesh has taken a decision that all the schools in the flood prone areas will be reconstructed as shelter to facilitate safe shelter to the affected people and also reduce extra burden on the schools during any disaster. In the Standing Orders on Disaster the roles and responsibilities of Directorate of Primary Education has been identified considering both Risk Reduction and Emergency Response. Different organizations like ActionAid Bangladesh, Oxfam GB, and Concern Universal are working on that for quiet some time. In Bangladesh one comprehensive Manual on School Safety has been developed by ADPC and Plan Bangladesh and Islamic Relief Worldwide Bangladesh with technical inputs from Handicap International. CARE is going to establish the school brigade which would help a lot to reduce the risks of the schools and make the school safe. For making the culture of safety the following strategy and steps could be taken:

- Government should take all necessary steps for implementing disaster related education issues mentioned in SoD.
- Government should review the seismic safety of the schools in the earthquake danger zone and prepare the School brigade.
- Ministry of Education and Ministry of Food & Disaster management of Bangladesh Government should introduce a 'School Safety policy' and should work for enforcing strict codes of conduct so that high standards are met in school construction.
- Develop School Safety Plan (SSP) focusing the school based teenager brigade and Strengthening the School Management Committees for implementing that. Prevention Fund should be introduced in the schools.
- Government should include the School safety as part of the national curriculum.

Government as well as non government organizations could play a vital role for achieving the culture of safety. As the students are the future of the nation, if the culture of safety could be established within them, it could be replicated automatically throughout all the sectors of the whole nation.

1 Introduction

1.1 Background and justification

Hyogo Framework for Action (HFA) 2005–2015, under its one of the priority area named "Building the Resilience of Nations and communities to Disasters" is trying to build a culture of safety and resilience at all levels. For making a community resilient to disaster HFA recognizes the vital role of school. The World Disaster Reduction Campaign for 2006-2007 by the UNISDR was carried out under the theme of "Disaster Risk Reduction Begins at School." Globally it has been seen that schools are used as shelter. But there are very little initiatives for making the school safe. Traditionally, in many countries including Bangladesh, small school buildings act as a relief or safe shelter during a disaster. Damage to school building complicates the relief activities or evacuation activities. Damage to educational institutions will disrupt the education system and eventually the development of the country. Children often need psycho-social support as they are one of the worst victims of disaster. Quick reopening of school after disaster has been proved to be an important psychosocial support as children get engaged in education and with their classmates. Safety helps to mitigate risk in any given situation. If precautionary measures are not taken against disaster then we might face problems related to human casualty as well as loss of resources. Moreover, the students are main firewood for rolling the country to forward. It is often said 'Educating a child leads to educating three generations' as, an educated child shares the knowledge with his parents at home and also with his kids when he becomes parent. Children are the most suitable 'Change Agent' and they can help in bringing disaster preparedness, mitigation and prevention in the society at large. If they are prepared, a culture of safety would be developed throughout the nation. Children are among the most vulnerable groups during disasters. Also, they are future of any society, hence their safety is paramount. Schools especially in rural areas are nucleus of community and a number of community activities including livelihood revolve around the school.

2 What is meant by culture of safety?

The U.K. Health and Safety Commission developed one of the most commonly used definitions of safety culture, which describes safety culture as: "The product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management" (HSC, 1993a, p. 23). According to ADPC "**Safe School**" is a process which attempts to ensure physical and psychological safety of students, teachers and supporting staff in the event of any disaster. It includes policy level interventions, multi-hazard resistant school infrastructure, continuous disaster preparedness, mitigation and prevention initiatives by students, teachers and other stakeholders." (School Safety Manual, ADPC, 2009, p.1). So when the school will own the value of Disaster Risk Reduction (DRR) and also take necessary measures to make them safe from different hazards, then the culture of safety would be established.

3 Bangladesh experience

3.1 Government initiatives

In 1997, Ministry of Education has taken some policy decision to disaster preparedness at educational institutions. After the devastating flood of 2004, Government of Bangladesh has taken a decision in 2005 that all the schools in the flood prone areas will be reconstructed

Figure 1. Students are gaining DRR knowledge through IEC materials in the school.

as shelter to facilitate safe shelter to the affected people and also reduce extra burden on the schools during any disaster. In the Standing Orders on Disaster (SOD) the roles and responsibilities of Directorate of Primary Education has been identified considering both Risk Reduction and Emergency Response. According to the SOD Directorate of Primary Education, besides its own work plan (contingency plan) and normal responsibilities will perform the following duties.

(a) Designate one Liaison Officer as the Disaster Management Focal Point.

(b) In consultation with the Disaster Management Bureau include disaster-related subjects in the curricula of all primary schools and mass education programmes.

(c) Ensure, as far as possible, the construction of all primary educational institutions as multipurpose disaster shelters.

(d) Prepare agency contingency plan and keep operationalized the agency contingency plan.

3.1.1 ActionAid Bangladesh (AAB)

AAB is working on that for quiet a long time. They tried to develop the contingency plans for the schools of *Chittagong* as well as *Dhaka*. They also raise awareness among the School Management Committee as well as the students of the school. While working on school safety, AAB felt the need of developing a comprehensive approach. Recently they are conducting one study for developing indicators of culture of safety for the school in Bangladesh on natural and manmade hazards through pilot testing. This study would also try to get some recommendations for mainstreaming culture of safety to into policy, programs and project on education in Bangladesh.

3.1.2 Oxfam GB

Oxfam GB is also implementing one project which also deals with the issue of School Safety. They are dealing with the adaptable measures which could be implemented by the students. The major focus of Oxfam GB's DRR program is to build the capacity and raise awareness of the students and teachers. For example awareness rising among the students, observing the NDPD etc.

Figure 2. Students are in the mock drill.

3.1.3 Concern universal

CU has developed the school brigade as a part of the school safety program. They have developed the brigade in thirty schools of *Barguna* and *Patuakhali* districts and build the capacity of around 900 students under the model of school brigade. The school brigade is working as key change agent considering the school safety. They are also trying to empower the voice of the School Brigade by involving them into different risk assessment process (for example government approved CRA process) and also with the Union Disaster Preparedness Committee.

3.1.4 Islamic relief

Islamic Relief with Plan Bangladesh has developed a comprehensive School Safety Plan (SSP) manual with the technical assistance of ADPC and Handicap International. The school safety manual was developed through a consultative process where various stakeholders were consulted to gather the required information. This SSP is the basis of their activities related to school safety. All the activities performed for the safety of the school like; Mock drill, awareness raising activities in the school, mitigation activities etc. was guided by the SSP. This activity

3.1.5 CARE Bangladesh

CARE Bangladesh under its SHOUHARDO program is going to establish the school brigade in the haor and char areas of Bangladesh. This school brigade would be an organized workforce to implement the activities related to School Safety Plan (SSP).

3.1.6 IFRC

IFRC with the help of BDRCS is working on School Based DRR program to raise awareness on cyclone preparedness in terms of new cyclone early warning signals, evacuation, and climate change adaptation.

4 How to develop the culture of safety in school

To make the school as well as the nation safe from disaster the culture of safety should be developed. But it will not come in a single day. A holistic approach needs to be taken. If any institutions have the following indicators updated then it could be said that it has the culture of safety.

- School prepared its School Disaster Management Plan.
- School Disaster Management Committee has been constituted.
- School Disaster Management Teams have been constituted.
- Mock drills are conducted at regular interval.
- School Disaster Management Plan is updated at periodic interval.
- School Disaster Management Plan is shared with all.
- Evacuation route cleared and exit gates are free of obstruction.
- Awareness on Do's and Don'ts of disasters takes place regularly.
- The School Disaster Management Team members have been trained.
- Basic safety equipments like First Aid kit, sand buckets, etc. are in school.
- List of updated important contact details is available.
- Disaster management has been included in the school curriculum.
- Building and its surrounding have been assessed by the technical experts for safety.

From the experience of different organizations, the following strategy and steps could be taken to develop the culture of safety.

4.1 Develop school safety policy

Ministry of Education and Ministry of Food & Disaster management of Bangladesh Government should introduce a 'School Safety policy' and should work for enforcing strict codes of conduct so that high standards are met in school construction. This policy should focus both structural and non-structural mitigation activities. Government should review the seismic safety of the schools in the earthquake danger zone and prepare the School brigade.

4.2 Develop and implement the school safety plan

Develop School Safety Plan (SSP) focusing the school based teenager brigade and Strengthening the School Management Committees for implementing that. This SSP should guide the school authority about the process of making the school safe. Prevention Fund should be introduced in the schools for developing and performing the SSP This school safety plan should be developed considering the following aspects:

- Hazards/Vulnerabilities of the Schools.
- Facilities/Resources for Schools for Ensuring Structural and non-structural Safety of School.

Figure 3. Using fire extinguisher as a part of SSP.

- Disaster Awareness, Evacuation Planning, forming and capacity building of Task Forces, conducting Mock Drill, defining Stakeholders' Roles and Responsibilities are the key aspects of any SSP.
- Sustainability of Risk Education because of the changing pattern of disaster
- The SSP should also consider the process of, providing psychosocial support for children in disaster situations, adaptation to Climate Change, inclusion of gender and persons with disability (PWDs) with the knowledge of Education in Emergencies and School Safety Audit

In the SSP developing process all the relevant stakeholders like Teachers, Supporting Staff, Parents, Education Department, Community leaders, Students, Service providers like Fire Services and Civil Defense, Gas and Electric authority, Police Force, Red Cross Society (MRCS), Engineers,. Doctors, local NGOs etc. should be involved

4.3 Implementing the responsibilities of SOD

Government should take all necessary steps for implementing disaster related education issues mentioned in SoD. In most of the cases the education institutions are used as shelters and the school authorities become active, in that time. But there are certain roles and responsibilities, which should be followed in the normal time to make the school safe. Teachers and School management bodies should be well aware and trained about the roles and responsibilities mentioned in the SOD for making the school safe.

4.4 Include school safety in the national curriculum

Government should include the School safety as part of the national curriculum. It should be part of their education. If it is the part of their education then teachers, guardians as well as students will take the issue very sincerely. This is a very important for sustaining the culture of safety in the school. By incorporating in the curriculum, the best practices of one school could be easily replicated by other schools.

5 Conclusion

Government as well as non government organizations could play a vital role for achieving the culture of safety. Government should take it as a priority so that each and every institution practices the culture of safety. For doing that government should necessary policy implications so that the concept of School Safety is implemented by all the organizations. For establishing the culture all relevant stakeholders should try to execute the roles and responsibilities, which is mentioned in the Standing Order on Disaster. NGOs should also take this as their one of the priority area to bring the issue into the operation level. As the students are the future of the nation, if the culture of safety could be established within them, it could be replicated automatically throughout all the sectors of the whole nation.

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Challenges in managing e-waste in India

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Abstract

The developing countries are facing a huge challenge in the management of electronic waste (e-waste) which are either internally generated or imported illegally as 'used' goods. E-waste contains hazardous constituents that negatively impact the environment and human health. In India, because of lack of adequate infrastructure to manage wastes safely, these wastes are buried, burnt in the open air or dumped into the surface water bodies. We should have in place legislation mandating electronic manufacturers and importers to take-back used electronic products at their end-of-life (EoL) based on the principle of extended producer responsibility (EPR). This paper gives an insight into various forms and the quantum of e-waste in the Indian scenario, the source and the circulation routes, the nature and the amount of toxic and valuable constituents of e-waste, potential pollution threat to environment, recycling methods, efficient management techniques for e-waste, awareness of people and legal requirements.

1 Introduction

Electronic waste, e-scrap, or Waste Electrical and Electronic Equipment (WEEE) is a loose category of surplus, obsolete, broken, or discarded electrical or electronic devices which have become out-of-use due to advancement in technology nearing the end of their useful life. This includes used electronic components and gadgets which are destined for reuse, resale, salvage, recycling or disposal. It is also disturbing to note that computer wastes containing hazardous heavy metals in large quantity are accumulating very fast.

Extended Producers Responsibilities (EPR): The most important component of any legislative exercise for establishing a WEEE management system should be a focus on EPR. The original motivation for EPR was: first, to relieve municipalities of some of the financial burden of waste management, especially when it comes to complex wastes such as e-waste, and, second, to provide incentives to producers to reduce resources, use more secondary materials, and undertake product design changes to reduce waste (OECD, 2001). The main E-waste sources are imports, government, public and private sector discards (over 70%), PC retailers and manufactures, secondary market of old PCs; and individual Households.

Table 1. Average composition of electronic waste.

Metals	60.2%
Plastics	15.2%
Screens	12.0%
Metal–plastic mixture	5.0%
Pollutants	2.7%
Cables	2.0%
Printed Circuit boards	3.1%

2 List of substances contained in electronic waste

An average composition of e-waste is given in the Table 1, while an average material constituent of consumer electronics which forms a significant component of solid waste stream is presented in Table 2.

On an average when one tone of e-waste is shredded and undergoes other separation steps during mechanical recycling, approximately 40 kg of dust-like material is generated containing precious metals, which are otherwise toxic if they exist in nature in high concentration. Substances found in large quantities include epoxy resins, fiber glass, Polychlorinated biphenyls (PCBs), polyvinyl chloride (PVC), and thermosetting plastics;

Table 2. Material composition of personal computer.

Silica/glass	26%
Aluminum	14%
Ferrous metal	20%
Plastics	23%
Lead, Copper, Zinc and Cadmium	17%

lead, tin, copper, silicon, beryllium, carbon, iron and aluminum. Elements found in trace amounts include mercury, cadmium, americium, antimony, arsenic, barium, bismuth, boron, gold, cobalt, gallium, nickel, platinum, rhodium, silver, tantalum, titanium, vanadium and yttrium.

2.1 Recoverable and recyclable metals contained in e-waste

The elements present in bulk include lead, tin, copper, silicon, carbon and iron. The devices containing theses elements are:

- Lead: Solder, CRT monitors (Lead in glass), lead-acid battery.
- Tin: Solder.
- Copper: copper wire, printed circuit board tracks.
- Aluminum: Heatsinks.
- Iron: Steel chassis, cases and fixings.
- Silicon: glass, transistors, ICs, printed circuit boards.
- Nickel and cadmium: rechargeable batteries.
- Lithium: lithium-ion batteries.
- Carbon: resistors.

The distribution of various metals present in personal computers is presented in Table 2.

3 Problems at large

(1) E-waste is a crisis of not quantity alone but also a crisis born from toxic ingredients, posing a threat to the occupational health as well as the environment.

(2) Rapid technology change, low initial cost, high obsolescence rate have resulted in a fast growing problem in our country.

(3) Legal framework, proper collection system missing.

Trade in electronic waste is controlled by the Basel Convention. This is an international treaty that was designed to reduce the movements of hazardous waste between nations. It does not, however, address the movement of radioactive waste.

4 Hazards to human health

Up to 38 separate chemical elements are incorporated into electronic waste items. Many of the plastics used contain flame retardants such as Polybrominated Biphenyls (*PBB*) and Polybrominated Diphenylebethers (*PBDEs*). Inhaling or handing such substances and being in contact with them on a regular basis can damage the brain, nervous system, lungs, kidneys and the reproductive system. In our country, people are unaware of these and are risking their life and environment as well.

Electronic waste hazards

'The cathode ray tubes (CRTs) in computer and television monitors contain lead — which is poisonous to the nervous system — as do circuit boards. Mercury — like lead — a neurotoxin, is used in flat-panel display screens. Some batteries and circuit boards contain cadmium, known to be a carcinogen.'

'When disposed in landfills, these products have the potential to contribute significant levels of toxic materials to the leachate produced in landfills. These include lead, polychlorinated biphenyls (PCBs), mercury, cadmium, arsenic, zinc, chromium, and selenium.'

'PVC is a chlorinated plastic used in some electronics products and for insulation on wires and cables. Chlorinated dioxins and furans are released when PVC is produced or disposed of by incineration.'

'PVC is a chlorinated plastic used in some electronics products and for insulation on wires and cables. Chlorinated dioxins and furans are released when PVC is produced or disposed of by incineration.'

Hazardous elements

- Americium: smoke alarms (radioactive source).
- Mercury: fluorescent tubes (numerous applications), tilt switches (pinball games, mechanical doorbells, thermostats). There are no liquid mercury switches in ordinary computers, and the elimination of mercury batteries in many new-model computers is taking place.
- Sulphur: lead-acid batteries.
- PBBs: Predecessor of PCBs. Also used as flame retardant. Banned from 1973-1977 on.
- PCBs: prior to ban, almost all 1930's–1970's equipment, including capacitors, transformers, wiring insulation, paints, inks, and flexible sealants. Banned during the 1980's.
- Cadmium: light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, nickel-cadmium batteries.
- Lead: solder, CRT monitor glass, lead-acid batteries, some formulations of PVC. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead, but other CRTs have been estimated as having up to 8 pounds of lead.

- Beryllium oxide: filler in some thermal interface materials such as thermal grease used on heat sinks for CPUs and power transistors, magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers.
- Polyvinyl chloride Third most widely produced plastic, contains additional chemicals to change the chemical consistency of the product. Some of these additional chemicals called additives can leach out of vinyl products. Plasticizers that must be added to make PVC flexible have been additives of particular concern. Burning PVC in connection with humidity in the air creates Hydrogen Chloride (HCl), an acid.

5 Scenario in our country

IT and telecom are the two fastest growing industries in the country. The statistics collected by 'Manufacturers Association for Information Technology (MAIT)' on the growth of electronics and IT industry in INDIA are:

The PC sales were over 7.3 million units during 2007–2008, growing by 16 percent.

The cellular subscriber base was up by 96.86 percent during 2007–2008. Its installed base is estimated to cross 300 million mark by 2010.

(1) *India by 2010, should achieve a PC penetration of 300* per 1000 from the existing 250 per 1000 (in 2007–08).

(2) At present, India has 35 million computers (on 2008). 75 million computers will be there by 2010.

(3) The Basel Action Network (BAN) which works for prevention of globalization of toxic chemicals as stated in a report that 50 to 80 per cent of e-waste collected by the US is exported to India.

(4) More than 2 million old PCs ready for disposal.

(5) Life of a computer reduced from 7 to 3 years.

(6) Memory devices, MP4 players, iPods etc. are the newer additions.

(7) Preliminary estimates suggest that the total WEEE generation is approximately 1,76,000 tons per year.

The consumers find it convenient to buy a new electronic device rather than upgrade the old one due to the changing configuration, technology and the attractive offers from the manufactures. Due to the lack of governmental legislation on e-waste, standards for disposal, proper mechanism for handling these toxic hi-tech products, mostly end up in landfills or partly recycled in an unhygienic condition or thrown into waste streams.

The Indian PC industry has been growing at a 45% compounded annual growth rate, a survey made by leading Indian computer magazine Data quest. At present Bangalore alone generates more than 10,000 tones of computer waste monthly and in the absence of proper disposal, they find their way to scrap dealers.

The Indian states in the order of their contribution to WEEE are as follows. [2] Maharashtra > Andhra Pradesh > Tamil Nadu > Uttar Pradesh > West Bengal > Delhi > Karnataka > Gujarat > Madhya Pradesh > Punjab.

Cities in the order of their generation of WEEE are as follows. Mumbai > Delhi > Bangalore > Chennai > Kolkata > Ahmadabad > Hyderabad > Pune > Surat > Nagpur.

According to the study conducted by the NGO Toxic Link [3], the Mumbai city faces grave health and environmental risk posed by a whopping 19,000 tonnes of electronic waste produced here apart from a good amount of same being imported clandestinely. The rate of generation and the current methods of disposal pose an adverse effect to the dense population and the environment [7]. Study by the Chittaranjan National Cancer Institute, Kolkata, found that people in Delhi are about twice as likely to suffer from lung ailments due to the huge amount of e-waste generated [3].

Workers in e-waste disposal sector are poorly protected as they dismantle the e-waste often by hand. About 25,000 workers are employed at scrap-yards in Delhi alone, where 10,000 to 20,000 tons of e-waste is handled every year.

Thus in India, the electronic waste is generated in huge amounts and there is no proper management method to handle this e-waste and also people are unaware of the health hazards and pollution these e-waste generate.

6 Recovery processes

The procedure of metal extraction includes *manual sorting, magnetic separation, reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration and centrifugation*.

Electronic waste processing usually first involves dismantling the equipment into various parts (metal frames, power supplies, circuit boards, plastics), often by hand. The advantages of this process are the human's ability to recognize and save working and repairable parts, including chips, transistors, RAM, etc. In an alternative bulk system, a hopper conveys material for shredding into a sophisticated mechanical separator, with screening and granulating machines to separate constituent metal and plastic fractions, which are sold to smelters or plastics recyclers. Such recycling machinery is enclosed and employs a dust collection system. Most of the emissions are caught by scrubbers and screens. Magnets, eddy currents, and screens are employed to separate glass, plastic, and ferrous and nonferrous metals, which can then be further separated at a smelter. Leaded glass from CRTs is reused in car batteries, ammunition, and lead wheel weights, or sold to foundries as a fluxing agent in processing raw lead ore. Copper, gold, palladium, silver, and tin are valuable metals sold to smelters for recycling. Hazardous smoke

Table 3. Table below shows the details of hazards of each element [9].

E-waste sources	Constituents	Health effects
Solder in printed circuit boards, glass panels, and gaskets in computer monitors	Lead	• Damage to central and peripheral nervous systems, blood systems, and kidney damage • Adverse effects on brain development of children; causes damage to the circulatory system and kidney
Chip resistors and semi-conductors	Cadmium	• Toxic irreversible effects on human health • Accumulates in kidney and liver • Causes neural damage
Relays and switches, and printed circuit boards	Mercury	• Chronic damage to the brain • Respiratory and skin disorders due to bioaccumulation in fishes
Galvanized steel plates and decorator or hardener for steel housing	Chromium	• Causes bronchitis
Cabling and computer housing	Plastics and PVC	• Burning produces dioxin that causes reproductive and developmental problems
Electronic equipment and circuit boards	Brominated flame-retardants	• Disrupt endocrine system functions
Front panels of CRTs	Barium, phosphorus, and heavy metals	• Cause muscle weakness and damage to heart, liver, and spleen
Copper wires, Printed circuit board tracks	Copper	• Stomach cramps, nausea, liver damage, or Wilson's disease
Nickel–cadmium rechargeable batteries	Nickel	• Allergy of the skin to nickel results in dermatitis while allergy of the lung to nickel results in asthma
Lithium-ion battery	Lithium	• Lithium can pass into breast milk and may harm a nursing baby • Inhalation of the substance may cause lung edema
Motherboard	Beryllium	• Carcinogenic (lung cancer) • Inhalation of fumes and dust causes chronic beryllium disease or beryllicosis

and gases are captured, contained, and treated to mitigate environmental threat. These methods allow for safe reclamation of all valuable computer construction materials.

The *bio-hydro-metallurgical* techniques provide us with a better solution i.e. to apply a *bacterial leaching* process (bioleaching) for the mobilization of the metals from the e-waste. Bacteria and fungi (Bacillus sp., Saccharomyces cerevisiae, Yarrowia lipolytica) have already been used to mobilize lead, Copper and Silicon from the printed circuit broads. At electronic scrap concentration of 5–10 g/l in the medium, Thiobacillus thiooxidans and Thiobacillus ferrooxidans were able to leach more than 90% of the available Cu, Zn, Ni and Al. Aspergillus niger and Penicillium simplicissimum were able to mobilize Cu and Sn by 65% and Al, Ni, Pd,Zn by more than 95% at a scrap concentration of 100 g/l in the medium. Leached and recovered metals might be reused as raw materials by the metal manufacturing industries. This method has a potential to reduce e-waste and raw material costs, and also provide income from e-waste.

7 Recycling programs

The E-Management strategies that can be adopted from 4 R's policy — reduce, recover, recycle and reuse.

7.1 Consumer recycling

Consumer recycling options include donating equipment directly to organizations in need, sending devices directly back to their original manufacturers, or getting components to a convenient recycler.

7.2 Donation

Consumer recycling includes a variety of donation options, such as charities which may offer tax benefits. The Environmental Protection Agency maintains a list of electronic recycling and donation options for consumers. The Donate Hardware List and the National Technology Recycling Project provide resources for recycling. However, local recycling sites that do not process waste products on site, and consumers that throw electronics in the trash, still contribute to electronic waste.

7.3 Takeback

Individuals looking for environmentally-friendly ways in which to dispose of electronics can find corporate electronic takeback and recycling programs across the country. Corporations nationwide have begun to offer low-cost to no-cost recycling, open to the public in most cases, and have opened centers nationally and in some cases internationally. Such programs frequently offer services to take back and recycle electronics, including mobile phones, laptop and desktop computers, digital cameras, and home and auto electronics.

Though helpful to both the environment and its citizens, there are some downsides to such programs. Many corporations offer services for a variety of electronic items, while their recycling centers are few in number. Recycling centers and takeback programs are available in many parts of the country, but the type and amount of equipment to be recycled tends to be limited.

7.4 Exchange

Many new for-profit electronic recycling companies purchase and recycle all brands of working and broken electronics, whether from individuals or corporations. Such companies also offer free recycling for old electronics without market value.

8 Conclusion

The present study reveals that the e-waste are going to become a great challenge for environmentalists and technologists as the rate of growth is much higher than the rate it is disposed, reused or recycled. There is an urgent need for improvement in e-waste management covering technological improvement, operation plan, implementing a protective protocol for the workers working in e-waste disposal and educating public about this emerging issue posing a threat to the environment as well as public health.

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An integrated approach of GIS, GPS and Google earth for Aila cyclone recovery efforts in Sundarban Area of West Bengal

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Sundarban delta
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ABSTRACT

Sundarban delta is biggest deltaic zone in the world, moreover the delta is famous for Mangrove plants and trees, tiger reserve forest and most comfortable habitat for aquatic animals and creatures. There have been several small villages present with in the Sundarban deltaic zone. The local population livelihood is mainly depending on fishing, agriculture and some sort of small scale kuitr business. The Sundarban delta area is adequate fertile and rich in crop sustaining mineral elements. Nature is having hands of justice and balancing the environment, moreover in year 2009. Month May, there was an impetuous water cyclone occurred in Sundarban area and washed out almost habitat area all along its rapid intensity. Post cyclone situation had become very worst and pathetic, many of lost their lives, many of lost their livelihood and many of injured and became roofless. To recover circumstance several humanitarian players arrived into the affected area and engaged themselves for lives resettlement and relief distribution. Sphere India New Delhi had been one of them in assisting information technology tool for better planning and sustainable development. Every planning is required a systematic and strategic cartographic solution for lasting hold up. GIS, GPS and Google earth provided best effective maps of the area of interest. Those maps are at large scale and at community level for their better and comprehensive understanding about village, resource, capacity, vulnerability, risk and hazards. The same product must be using by implementing agencies for indeed requirement of community development.

1 Introduction

The Aila cyclone took place in year 2009 May, in Sundarban delta area of west-Bengal. This had happened first time in the history when such a devastative water cyclone occurred and damaged thousands of lives. Geographically area is more or less a flat terrain and some where the elevation is below the datum line. Population density is very least to moderate in some part of the bigger villages. Most of the population resides at the bank of the very wider rivers; there is a network of wider and Dynamic Rivers which makes a beauty of the area. Embankments closing the rivers are very weak and non-cemented in most of the areas. The rivers are developed due to the back water of the Bay of Bengal. Due to that those catch and connect with natural processes of high tide and low tide. The high tide process is an often challenge for the community and to their livelihood. Due to a highly vibrant onslaught of the cyclone in 2009, most of the villages of the Sundarban went under disruptive damage, embankment converted into flat terrain, for the miles of area changed into a bigger water body with house plankton. The area seems to be a stagnant water body with floating houses. No permanent shelter above the minimum heights found in the area. Peoples with their ample understanding were trying to resettle within the village. However they got success and found themselves alive with very poor condition after the sea water regression. When the news about the disaster broke into the public, local NGOs reached very quickly into the field of aid, some other UN NGOs and INGOs also arrived with the food and non food items. There were several numbers of agencies emerged and centralized for best effective assistance at a single platform with various requirement of the community. This was a haphazard and random relief distribution from the various agencies to the community. Some natural capacities have been standing against such water calamities known as mangroves and other coastal plantation and trees. Thorough the GIS, GPS and Google Earth mapping, it has been found that the lost are proportionally less against the dense mangroves and vise versa. GIS, GPS and Google Earth are the emerging technical tools of an extensive mapping at all possible level. The product of GIS based technology has made development implementation work easiest. GIS, GPS and Google Earth have been used in later phase of the recovery to evaluate a present situation around the target areas. Using GIS, GPS and Google Earth, features of interest have been mapped out and presented in user friendly graphical view. Some sort of proactive mapping has been done apart from the natural and physical features, includes, Resources, vulnerability and capacities. This makes a comprehensive understanding and creates a transparent picture to take some possible mitigation steps towards community development. While having a glance at the GIS based map and its understanding about in context of their utility, community themselves is having a scope of development, suggestion and sustainable planning.

2 Topography and geological background

The topography of the area is almost a flat terrain surrounded by backwater and mangrove plantation. There is disperse communities mainly depend on agriculture for their livelihood. The area is enough rich in fertility due to the sediment deposition brings by the rivers. Most of the area is covered by natural mangrove forest which is strength for the community and habitat for aquatic creature. Most of the part of the Sundarban is covered by backwaters. Lithologcially the whole area is composed by sand and silt mixed with marine salt deposits and clay. Soils of the Sundarban mangrove forest differ from other inland soils in that they are subjected to the effects of salinity and waterlogging, which naturally affect the vegetation. In places soils are semi-solid and poorly consolidated. The pH ranges widely from 5.3 to 8.0. Although the Sundarban soil is in general medium textured, sandy loam, silt loam or clay loam, the grain size distribution is highly variable.

Geographically the entire area of interest falls in following coordinate points. 21°54′21.79″N Latitude to 88°24′19.82″E Longitude 21° 46′ 44.31″N Latitude to 88°30′19.33″E Longitude

Area Coverage — The Sundarban was originally measured (about 200 years ago) to be of about 16,700 sq km.

Forest Cover — The forest lies a little south to the Tropic of Cancer between the latitudes 21°30′N and 22°30′N, and longitudes 89°00′E and 89°55′E.

3 Village of interest and findings

The entire Sundarban area is having out of finger counting villages, the attack of the cyclone had been on entire Sundarban area including; forest animals and creatures. The all villages somehow affected very worst and out of those worst villages few of very worst villages have been selected for recovery objective and community based needs assessment. There are seven villages which have been selected for best practice of prototype development.

Name of the Villages, had been selected for GIS, GPS and Google Earth Mapping.

(a) Khakhali – 4
(b) Khakhali – 8
(c) Bangheri
(d) East – ShriPatinagar
(e) West – ShriPatinagar
(f) Banshyamnagar
(g) Koyemudi

The all above mentioned seven villages belong to two different blocks of Nimpith District.

Features of interest which have been collected during the GPS mapping are as following;

There are four basic features have been collected during GPS survey or mapping.

(A) Capacities.
(B) Resources
(C) Vulnerabilities
(D) Risk

All along the GIS mapping, features which have been extracted are as following;

(A) Water Bodies
(B) Population Delineation
(C) Roads
(D) Drainages
(E) Mangroves

In following table, various elements are collected or mapped mainly in two form point and polygon. Most of the point data collected using GPS and some of features which were not possible to map out using GPS have been mapped from the Google Earth.

Except Mangrove rest features in following table have been mapped out using GPS.

Google Earth played its crucial role in polygon and line mapping. Some of the very imperative features of the objective could not possible to map out using GPS, thus, have been mapped out from Google Earth are as flowing;

(A) Water Bodies
(B) Population Delineation
(C) Roads
(D) Drainages
(E) Mangroves

Table 1. This is a complex mapping done through GPS, Google Earth and in GIS environments.

Sl. No	Capacities	Resources	Vulnerabilities	Risk
1	Boats	Hand pumps	Vulnerable Houses	Weak Embankment
2	School	Solar energy System	Vulnerable Market	
3	Post Office	Bank	Vulnerable shops	
4	Hostel	Temple	Weak Pool	
5	Shelters	Dish TV		
6	Health facilitators	Shop		
7	Canal gate	Biogas Plant		
8	Electricity Pole	Mosque		
9	Police Camp	SSK		
10	VCC/Club/VDMC	Poultry Form		
11	ICDE	Fertilizer shops or IFFCO		
12	Cinema Hall	Market Place		
13	Vibha Center			
14	Veterinary			
15	Mangroves			
16	PCO/STD			
17	Dispensary			
18	Cooperative Sammiti			

4 Demonstration of prototype and its down-to-earth understanding at community level

GIS and Remote sensing is a technical scope of making highly beneficial out put and application for the target, initial it could be difficult to understand the core concept and technical outlook of the product.

As a part of project and the end user, it was very imperative to conduct a day workshop on GIS and Remote Sensing product understanding and their lasting impact and use while and during any natural catastrophe to take some positive response against. Apart form this, using the same product or output how a off technical or country person would be able to take some decision for planning or how technically it could be refer to government or an NGO for mitigation or planning.

The workshop was mainly conducted to explore target community and end user of GIS and Remote Sensing product. All along the program there were some few decisions or understanding facts made it out by the community are as following.

- This product provides an overall perspective view of the each village.
- It gives an idea about the field of development.
- On the basis of the output some planning decision can be taken for safety point of view.
- While having routine interaction with the GIS map, the whole parameters facilitating a map can be use during the disaster.
- It gives knowledge of the Resources, capacities, vulnerabilities, risk, hazard and other physical and natural features which may and may not be a part of practice.
- After all community able to understood use and where and how this output can be bring for appropriate work.

5 Summary

GIS and other mapping tools have proven their most effective and time favorable capacities in Aila cyclone recovery phase. GIS based drawn product has been emerging with pioneer concept and decision making & planning. The interactive GIS product has made its normalize facility to community and also to planner and developers. Maps from the area of interest are making their exclusive utility and generating a comprehensive and extensive image to understand present requirement for reinforcing the future. The availability of various parameters within the villages is ensuring community for disaster preparedness, emergency management and response. The GIS based maps for Sundarban community have developed in local jargon so that a layman can understand about the usefulness of the product. Resources, Capacities and Vulnerabilities make its maximum transparency to target peoples.

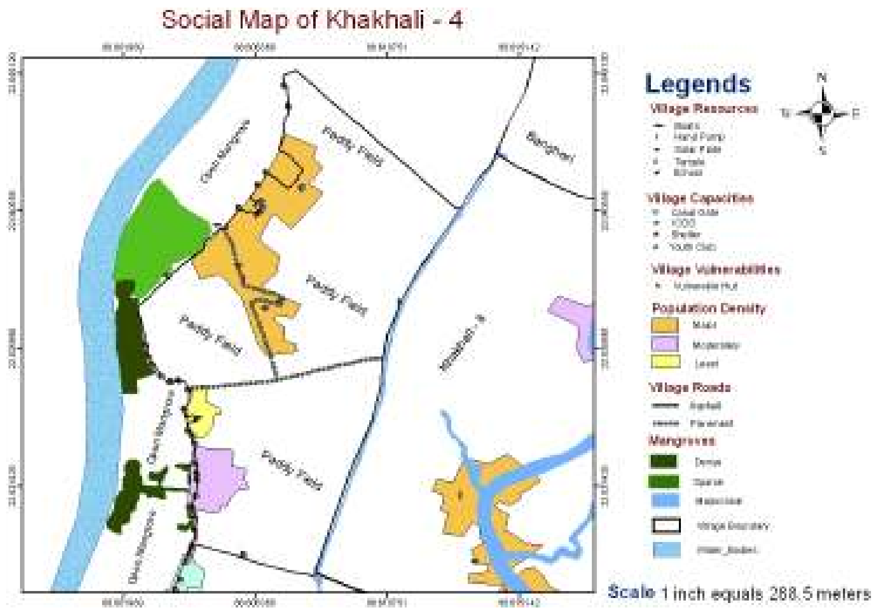
Sundarban area is very popular for its exclusive, attracting natural view. The area with diversified nature and habitat makes a captivating craze for the visitors.

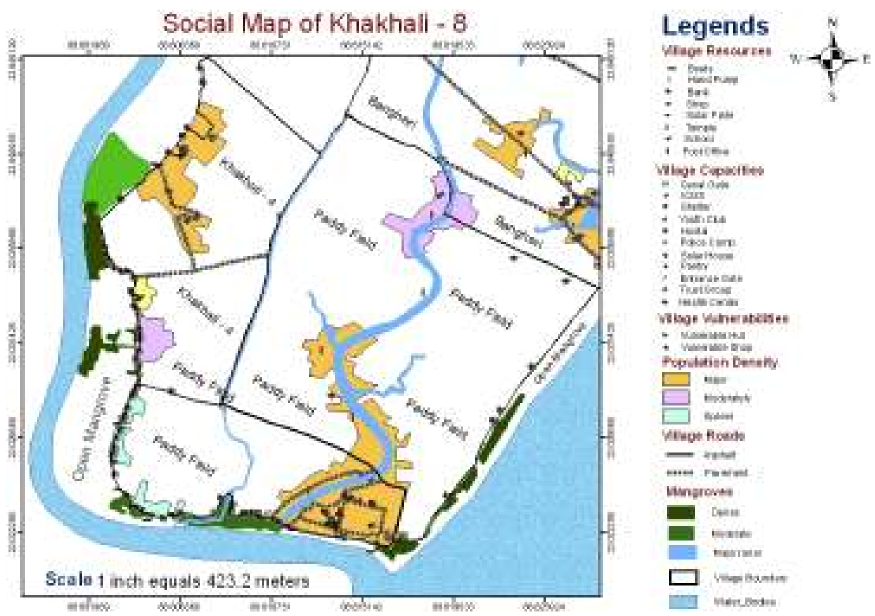
Aila Cyclone in year 2009 May, had been very destructive and devastative, uprooted charm of the area and made it as a land with abnormal view.

6 GIS based maps

The Maps are showing a conspicuous and an exclusive scenario of the respective village.


Methodology
GPS
Capacities Mapping
Resources Mapping
Vulnerabilities Mapping
Google Earth
(Remote Sensing)
Population Density
Mangroves Mapping
Water Bodies
Roads Mapping
Village Boundary
GIS Editing
GIS Map Layout
and Map Finalization


Social Map of Khakhali - 4
Legends
Village Resources
Village Capacities
Village Vulnerabilities
Population Density
Village Roads
Mangroves
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Scale 1 inch equals 288.5 meters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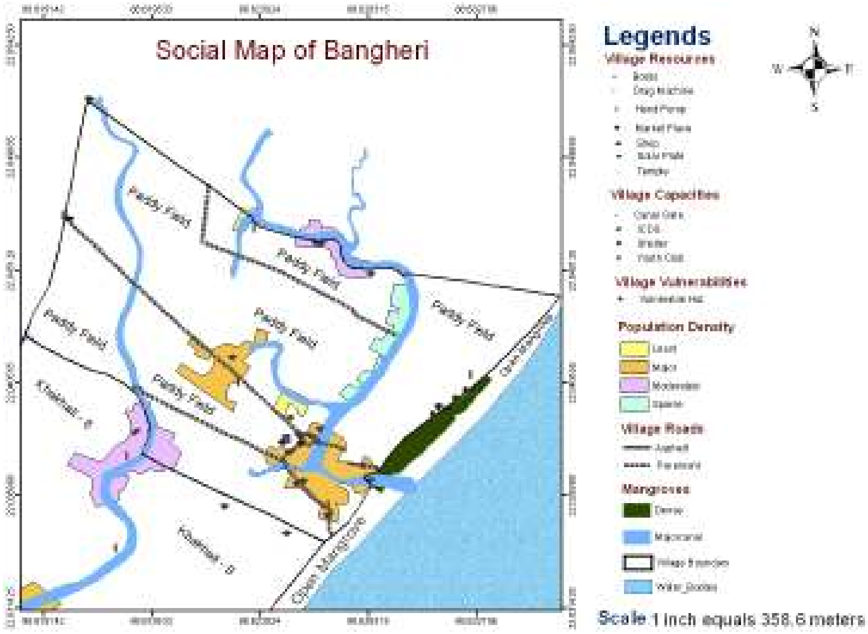
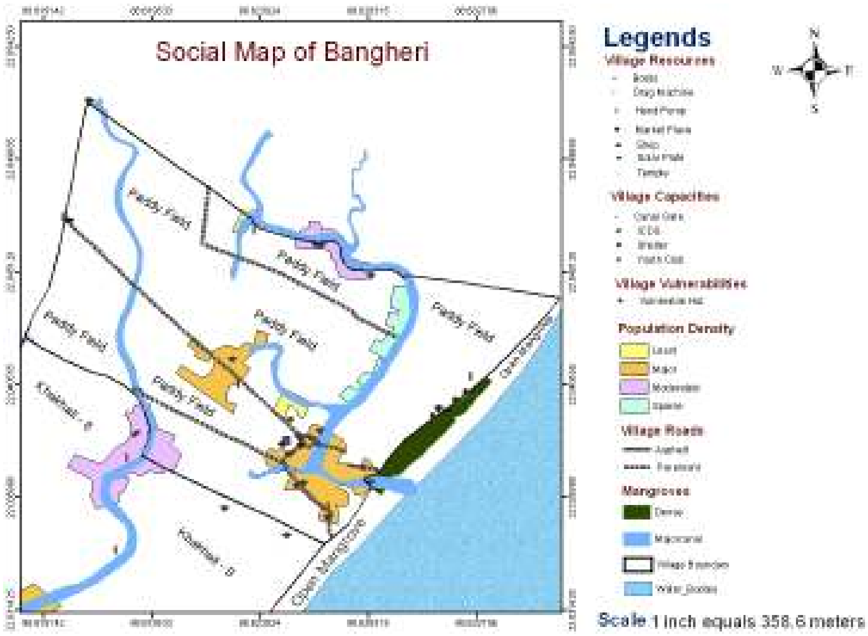
Legends
Village Resources
Village Capacities
Village Vulnerabilities
Population Density
Village Roads
Mangroves
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Open Mangrove
Scale 1 inch equals 423.2 meters


Social Map of Bangheri
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Open Mangrove
Legends
Village Resources
Village Capacities
Village Vulnerabilities
Population Density
Village Roads
Mangroves
N
W
S
Scale 1 inch equals 358.6 meters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Paddy Field
Paddy Field
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Paddy Field
Paddy Field
Open Mangrove
Legends
Village Resources
Village Capacities
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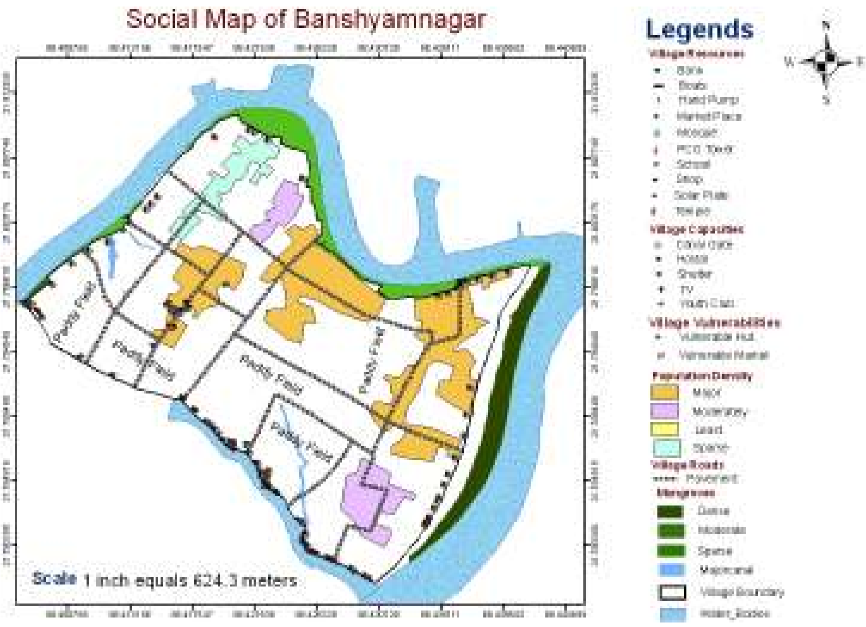
Population Density
Village Roads
Mangroves
N
W
S
Scale 1 inch equals 358.6 meters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Paddy Field
Paddy Field
Paddy Field
Paddy Field
Paddy Field
Legends
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Population Density
Village Roads
Mangroves
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E
S
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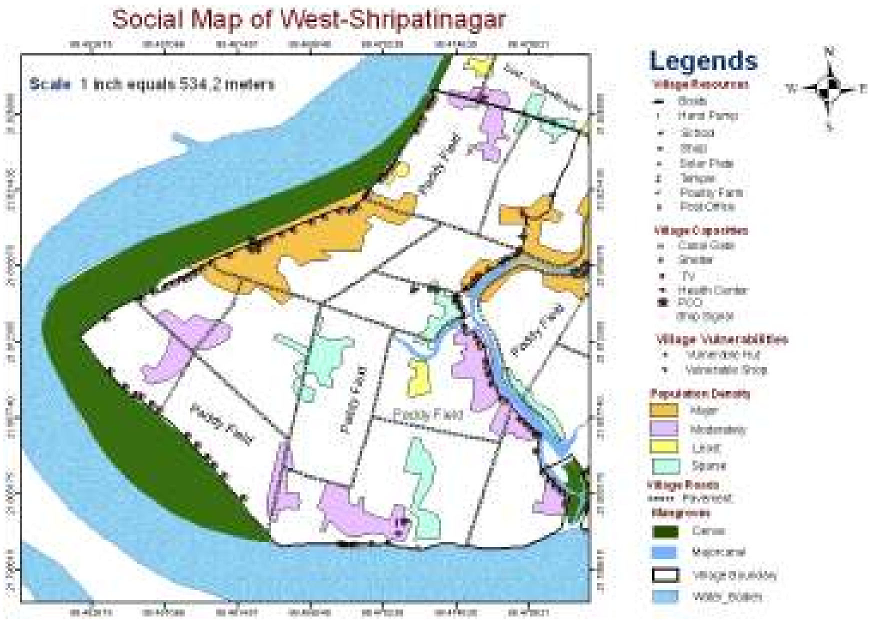
Social Map of West-Shripatinagar
Scale 1 inch equals 534.2 meters
Paddy Field
Legends
Village Resources
Village Capacities
Village Vulnerabilities
Population Density
Village Roads
Mangroves
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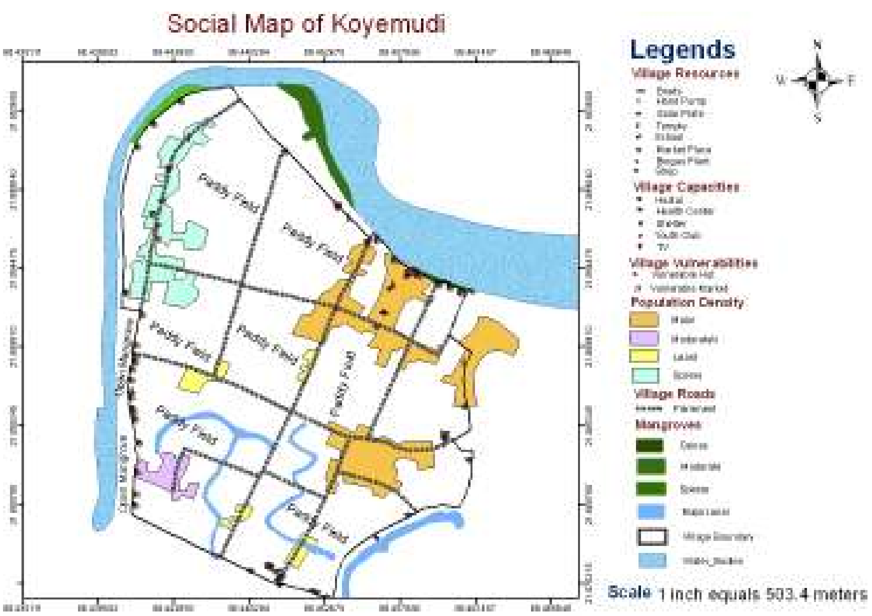
S
E
W


Social Map of East-Shripatinagar
Paddy Field
Legends
Scale 1 inch equals 584 meters
N
S
E
W


Social Map of Koyemudi
Paddy Field
Legends
Village Resources
Village Capacities
Village Vulnerabilities
Population Density
Village Roads
Mangroves
Scale 1 inch equals 503.4 meters
N
S
E
W

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An investigation on road accident prone curves of national highway 220 in Kottayam district, Kerala

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ABSTRACT

Transportation is a sector of major concern in any country in relation with the increasing demand of population growth, logistics operations and development. As the road networks and vehicles are increasing, the road accidents are also increasing at different rates and coverage. More than a quarter million people die in road accidents every year worldwide and about 60000 are from India alone showing the severity of the problem in our country. India moves fast to meet the diverse transportation needs making the country as the second largest in road network density in the world. The development of transportation sector and the transportation hazards are diverse among the states in India, of which Kerala state's ranking falls within the first five as far as the road accidents are concerned. The peculiarity in geographical settings of the state has a major contribution to the pattern and extension of roads. The road networks passing through hilly terrains are prone to road accidents of different types, namely collision and falling down through the steep slopes from the unprotected or semi protected sides of the roads. Identifying the highly accident prone areas and taking proper structural and non structural mitigation measures has potential importance. A stretch of National Highway passing through the Kottayam and Idukki districts of Kerala has been selected for the present study with an intention of evaluating and delineating accident prone locations. Geographical Information System based methodology was adapted to delineate the accident prone micro stretches. The results obtained were compared with the accident statistics and field survey and points out that the methodology used in the present study can be used for micro and macro scale zonation of road accident prone areas in the meandering type of roads in hilly regions such as in the midland topography of Kerala state.

1 Introduction

Road transportation is still considered as the dominant and preferred mode of transportation in account of its coast effectiveness and coverage. In India, the road net works comprised of National Highways, State Highways, District Roads and Village roads which facilitates the movement of both men and goods across the county due to its increased accessibility to Individuals all over the country. The road transportation sector is needed to be competent with the increasing infrastructure developments and Industrialization. Unfortunately, this vital part of development may lead to significant loss of lives due to the inadequate attention to safety systems and actions. The problem of deaths and injury as a result of road crashes is now acknowledged to be a

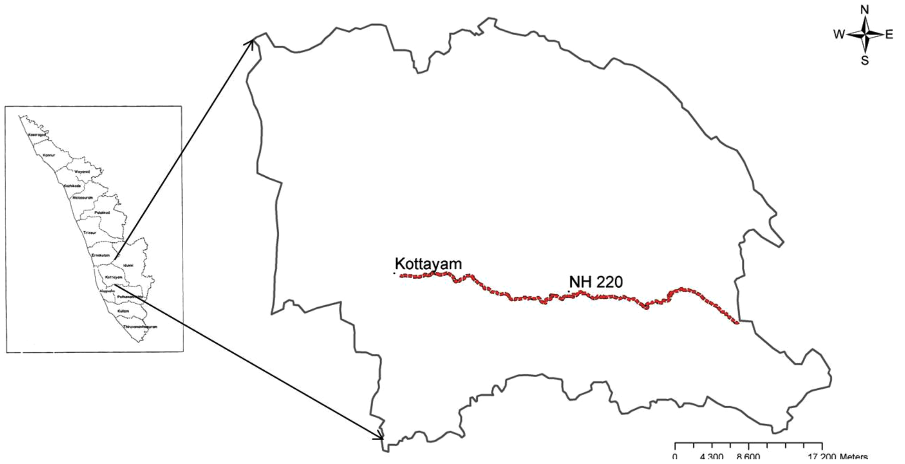

Figure 1. National Highway 220 connecting Kottayam and Kumily is shown in red color.

global phenomenon and virtually in all countries of the world are concerned about the growth in the number of people killed and seriously injured on their roads (Shah *et al.*, 2003). Global estimates show that nearly 3,500 people die on the world's roads every day and tens of millions of people are injured or disabled every year (WHO, 2011). Hence reliable and accurate data are also needed to properly identify problems, risk factors and priority areas, and to formulate strategy, set targets and monitor performance with an aim of raising awareness about the magnitude of road traffic injuries, and to convince policymakers (WHO, 2010).

1.1 Road accident at an alarming rate

The death and injury caused by road accidents are becoming a serious issue in many developing countries including India. According to the experts at the National Transportation Planning and Research Centre (NTPRC) the number of road accidents in India is three times higher than that prevailing in developed countries. The number of accidents for 1000 vehicles in India is as high as 35 while the figure ranges from 4 to 10 in developed countries (IHIF, 2010). The road accident records of 30 years (1970-2001) clearly indicate the increasing accidents in India from 114,100 to 394,800 reported cases with 3.5-fold increase (MRTH, 2004). In this period, annual road fatalities have increased from 14,500 to staggering 80,000, and the number of people injured in accidents has risen from 70,100 to 382,700.

1.2 Road accident research

An examination on the causes of each road accidents will give a congregation of so many unique factors hence the studies on accident could not be limited with a single aspect. The reasons include the vehicle condition, characteristics of the driver (ignorance, unawareness and unfamiliarity), road condition, traffic density etc. Accidents statistics point out that some particular sections of roads are frequently met with accidents including different kinds of vehicle. In such situation, the primary reason would be the condition of the road. To explore this problem deeply, a methodology should be adopted that exhibits potential for reducing frequency of road accidents by adopting suitable site specific measures at high accident risk prone stretches (Rautela, 2007). The present study is adopted with an objective of implementing a scientific methodology to delineate the road accident prone areas in the mountainous roads. The National Highway 220 (From Kottayam to Mundakkayam) has been selected for the present study (Figure 1) with an objective of delineating accident prone road stretches.

2 Methodology

The NH 220 is formed of enormous curves of different angles as it is connecting the midland portion of Kottayam district and highland regions of Kottayam and Idukki districts. As the road proceeds to hilly terrains, it meets several accident prone areas where the roads were constructed by steep slope cutting. Vehicle turns over to steep valleys and moving collision are reported occasionally in highly curved stretches. To identify the accident prone stretches, Sinuosity Indexing method was adopted in the Geographical Information System (GIS) platform. The study utilized the strength of GIS in studying the geographical correlates that attributes the accident proneness. Terrain information for the study area has been extracted from the Survey of India topographic sheets.

2.1 Sinuosity index

The ratio of length of a given road stretch and the aerial distance between the end points of the same road stretch (Figure 2) is defined as Sinuosity Index (Rautela, 2007). For the present study, Sinuosity Index (SI) is considered as the unit for assessing the curvature of the road. Sinuosity Index would be unity for a straight road stretch and its value would keep on increasing with roads becoming increasingly sinuous (curving). An increase in Sinuosity of the roads will become a major factor responsible for road accidents in hilly areas because of (a) reduce the visibility across the curves (b)

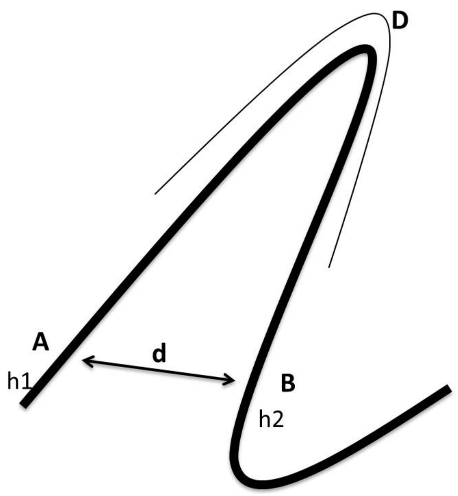

Figure 2. Sinuosity Index of a stretch A-B, SI=the ratio of actual distance (D) to areal distance (d).

Table 1. Sinuosity values of 5000 m road stretches.

Stretch code	Sinuosity index
1	1.08799751210
2	1.26609274100
3	1.09404581720
4	1.18098262954
5	1.41607345398
6	1.31746461020
7	1.11732591772
8	1.49137584631
9	1.09686645452
10	1.25608038492

Speeding vehicles not being able to negotiate the curves and (c) Fatigue caused in negotiating recurrent curves.

2.2 Calculation of sinuosity index

For calculating the Sinuosity Index, the road under consideration has been digitized using ArcGIS 9.1 software and it has been fragmented in to successive stretches of 5000 meter using the split tool. Sinuosity calculation Arc Script (visual basic) developed by Mathew Bull in 2005 was added as an extension tool in the Arc Toolbox. The Arc Script calculated the sinuosity values of each stretches of roads and the values obtained are given in table 1. Based on the Sinuosity values of 500 meter stretches, the road stretches were resampled into three classes, such as low sinuosity (1.002453 – 1.200000), moderate sinuosity (1.200001 – 1.700000), and high sinuosity (1.700001 – 2.200000) as indicator of accident risk and are given in Figure 3.

3 Sinuosity Index - 500 meter

During the Sinuosity calculation of 5000 m stretches, the roads in some points were dissected at the center of the curves. This has lead to low sinuosity values of the same places. To eliminate the error, the stretch has been

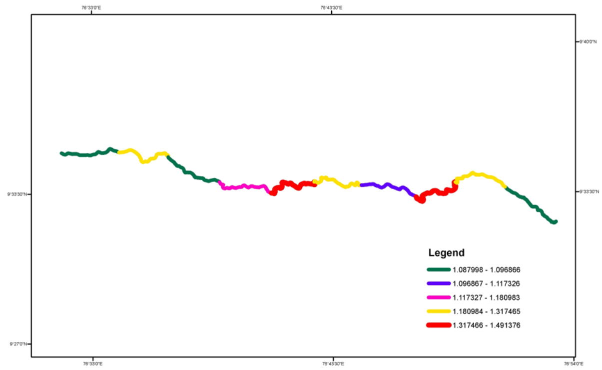

Figure 3. Accident prone stretches in 5000 m Sinuosity index.

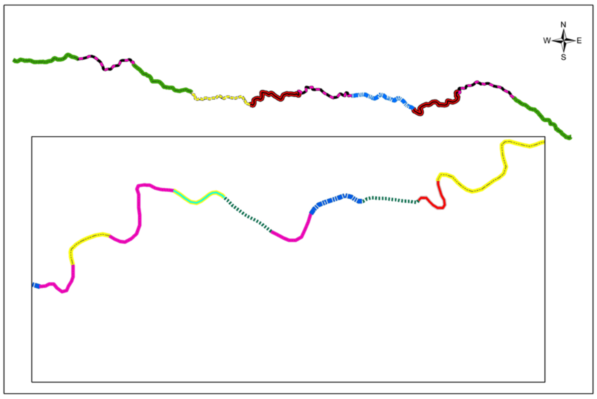

Figure 4. Accident prone areas derived from the 500 m sinuosity calculations. High risk stretch is given in red color.

divided in to the segments of 500 m and its corresponding Sinuosity values were calculated for micro-zonation. The obtained values and its geographical representation are shown Figure 4. The risk prone areas identified from the 500 m sinuosity Index were overlaid to the 5000 m divisions. High risk stretches are shown the same values and it falls to the previously identified risk prone mega stretch (Figure 4).

4 Conclusion

Managing vehicular accidents in roads is one of the major challenges faced by the governing bodies and operational departments since the long time. An effective road accident management strategy would include deliberate researches to explore the factors leading to accidents with an intention of developing appropriate intervention measures. One key factor which increases the accident vulnerability is the road condition. The present study has explored the appropriateness of a GIS based road accident zonation methodology based on the sinuosity of the road stretches. The pilot study in the National Highway 220 connecting Kottayam and Kumily of Kerala delineated the accident prone areas in macro and micro-scales. A comparative study of the accident statistics and field checking in the study area designate that the defined methodology is effective in planning structural and nonstructural road accident mitigation measures. The accuracy of the model could be improved with further studies taking in account of more physical parameters which increases point source accident vulnerability.

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Critical reflections on post disaster recovery and reconstruction in Andaman & Nicobar islands

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ABSTRACT

The article examines the post-disaster recovery and reconstruction activities to the major and minor disasters which are frequently disturbing the life of the islanders. The paper is focusing on the various actions taken by the A & N Administration as well as the social and developmental organizations, extracting lessons learned and identifying specific implications towards the episode. The sudden occurrence of the frequent earthquake distracts the normal life of the islanders and it hit in almost all part of the areas of the Andamans including North, Middle and Southern parts. The paper is at first attempt to review the recovery and reconstruction activities of the various stakeholders in relation with the December 2004 tsunami and earthquakes. Later the author pointed out the frequent incidence of the various disasters especially earthquake, flood and climate related disasters. Lessons that have been learned from the post-disaster response are summarized, including: (a) lessons that apply primarily to the relief phase; (b) lessons for rehabilitation and reconstruction; (c) do's and don'ts; (d) island specific observations. (e) finally the impact and the long term implications of the intervention on the livelihood of the islanders in the post disaster response period. The author describes his experience and tries to analyze the role of administration and the various other stakeholders in the areas of disaster recovery and reconstruction. The author finally suggested the unavoidable elements needs to be incorporated in the post disaster response phase.

1 Introduction

For the first time in half a century, India experienced the devastating effects of a tsunami, caused by a series of earthquakes in the Bay of Bengal. The first and strongest earthquake occurred off the west coast of northern Sumatra, Indonesia at 6.29 AM Indian Standard Time on December 26, 2004 (magnitude and intensity 9.0 USGS), followed by one 81 kilometers (km) west of Pulo Kunji Great Nicobar, India (7.3 USGS) some three hours later. 115 aftershocks were reported, of which the magnitude of 103 tremors was between 5.0 and 6.0 USGS and 12 were over 6.0 on the Richter scale. The earthquakes set off giant tsunami tidal waves of 3 to 10 meters in height, which hit the southern and eastern coastal areas of India and penetrated inland up to 3 km, causing extensive damage in the Union Territory (UT) of the Andaman & Nicobar Islands, and the coastal districts of Andhra Pradesh, Kerala and Tamil Nadu and the UT of Pondicherry. Approximately 2,260 km of the coastal area besides the Andaman & Nicobar Islands were affected. The last time a tsunami hit the coast of India was in 1945. The other Asian countries affected are Indonesia, Maldives, Myanmar, Sri Lanka and Thailand. Several countries in East Africa have also been affected (NDMA, 2007).

Tsunami while causing damage to coastal environment also accentuated the degradation of the coastal ecosystems and aquaculture. The impact on agriculture land along the coast was significant. Land was salinated, which led to a considerable of crops. One of the least measurable impacts though is the effect that the catastrophe has had on the human mind and soul. The disaster took away lives, caused injuries and destroyed families, homes, and livelihoods. There are long-lasting effects on families due to death and injuries, for widows, single parents and their children, orphans, children separated from their families, the elderly, and the disabled. It is essential that recovery and rehabilitation work also focus on the long-term needs of the affected population in a holistic way. Following the post-Tsunami rapid assessment and analysis conducted by the Joint Assessment Mission (JAM), the United Nations Country Team in India continued to work in the spirit of close inter-agency cooperation to design a joint programme - the UN Tsunami Recovery Framework. Participating agencies included: UNICEF, UNDP, WHO, ILO, FAO, UNFPA, UNV and UNESCO. At the national level, a Tsunami Steering Committee was formed to oversee the immediate relief efforts, mobilize resources to fund the Recovery Framework, and direct the operational team working in the affected areas, i.e. the UN team for Tsunami Recovery Support (UNTRS).

2 Disaster relief and rehabilitation

Any disaster leaves larger range of damages and huge loss. While looking in to the Disaster Response in Haiti — a most important and fundamental example which draw in to the mind that the building and coordinating strong multi-disciplinary, multi-sectoral teams, is perhaps the most important lesson to learn from disaster relief and recovery generally, and from the recent experiences in earthquake ravaged Haiti. It is essential that disaster relief and recovery teams are led by national authorities, with a clearly designated leader and well defined roles and responsibilities. To enhance coordination, there needs to be clearly defined operating strategies and communication mechanisms within, among and between government agencies, national groups and international organizations. This is important to properly manage receipt, use and accountability of the unprecedented generosity in the form of pledges, material and human resources to Haiti. Attention to good governance is a fundamental building block of post disaster relief and recovery efforts. Integrating public participation, transparency and accountability into both the relief and recovery phases pays off in terms of better planning, improved implementation and reduced corruption. Disasters attract non-governmental organizations (NGOs) of all kinds, from all over the world, some operating within a very thin line of legitimacy. In fact, the experience in Haiti has coined a new phrase of 'mercenary NGOs'.

In post-disaster situations, most established and legitimate organizations that provide disaster relief already have well defined response systems that include their own experienced staff (paid or volunteer). They also generally incorporate local persons who are already in the area, familiar with the socio-economic systems and who can be quickly trained to support disaster relief and recovery efforts. Experiences from around the world provide indisputable evidence that relief and recovery efforts will be more effective if they identify, use, and strengthen existing social capital, i.e., community-based skills, programs, and networks. The community-driven approach to post-disaster recovery, which builds on this social capital, requires significant investments of time and human resources but has results in greater client satisfaction, more rapid disbursement, and local empowerment. The bottom line! The following points clearly describe the importance of the effective post disaster management activities in the context of a disaster or similar kind of episode.

- Disasters have put development in the region at risk!
- If managed properly, relief and recovery efforts provide opportunities to rebuild!
- Relief and recovery are temporary and supportive mechanisms for disaster management.
- Relief focuses on reducing factors that predispose harm from hazards!
- Recovery focuses on reducing human suffering as the basis for rehabilitation and Reconstruction!
- Relief and recovery efforts must provide a firm base for the rebuilding process!
- Relief and recovery will be more effective if they identify, use, and strengthen existing Social capital (Managing Development amidst Natural Hazards (USAID-OAS, 1999).

3 Post tsunami recovery and reconstruction in A & N islands

The post-tsunami period in the Andaman and Nicobar Islands offered an opportunity to restore affected housing and living conditions of the large number of people whose homes were destroyed or badly damaged. Such a process of restoration of people's lives needed to take place, keeping in mind basic human rights principles of gender equality, nondiscrimination and participation. It was clear, however, that even one year after the Tsunami, many shortcomings remained in the process of resettlement and rehabilitation. There is one important aspects is that all actors involved in relief and rehabilitation work must be undertake efforts to make sure that the grave mistakes made in post-disaster experiences of the past are not repeated. Failure to comply with human rights standards immediately will deepen the human-induced tragedy already afflicted on the survivors of the Tsunami. The resolve shown by states and the international community in the immediate aftermath of the tsunami must not be allowed to dissipate. In the process of rebuilding the lives, livelihoods and homes of those affected, it is vital that immediate humanitarian needs be complemented with long-term rehabilitation and reconstruction based on international human rights standards which uphold survivors rights to dignity, equality, livelihood, and to adequate conditions of living.

The feedback which the author collected from various stakeholders especially disaster survivors from Bamboo flat, Tushnabad,Vandoor and other parts of the South Andaman points out in detail that the inadequacy of response from the authorities, evident during the initial relief efforts period to the reconstruction phase, keep promising without utilizing resources and efforts, continues to mark the landscape. Clearly, the opportunities that the post-tsunami phase offered have been squandered by the authorities. One distinct human right, essential in any rebuilding process, is the right to adequate housing. A key element of this human right is 'cultural adequacy'. As stated by the UN Committee on Economic, Social and Cultural Rights: 'The way housing is constructed, the building materials used and the policies supporting this must appropriately enable the expression of cultural identity and diversity of housing. Also vital to the success of any rebuilding process, and related to the element of cultural adequacy, is that authorities grasp the opportunity to train local masons and utilize local building materials and respect local traditions of space usage and layout. Another crucial point which came from the survivors is the implementation of the right to adequate housing, including the standards of cultural adequacy, have been ignored in the reconstruction phase.

The A & N Islands government reconstruction programme to replace nearly 10,000 homes that were destroyed has thrown up many important issues. Major concerns voiced by communities include the design, location and cost of proposed housing and the lack of scope for them to be involved in the process. The livelihood and medical concerns of the affected ones are not met and often neglected. From the southernmost and hardest hit island of Campbell Bay, home to people from the Nicobarese tribes to Little and South Andaman where number of deaths was fewer but damage to homes and livelihoods extensive. Interviews were also conducted with officials and contractors. (Dharam P, 2007)

3.1 Housing

Related to the housing design and plan, though the traditional houses have withstood earthquakes very well and communities say they prefer them, the Government has decided to construct houses using pre-fabricated materials. These would be imported from mainland India through contractors at an apparently exorbitant average cost of approx. Rs.10 lakh per unit. People have rejected this type of houses. The anger of the marginalized communities of A & N Islands recently was manifested in a protest against the Government in Little Andaman which left more than 100 people injured in police action. Similar sentiments continue amongst inhabitants of other islands as well. (Vivek R, Rajendra D, & Dharmesh J. 2006). Despite the diverse backgrounds and wide range of lifestyles of communities in A & N Islands, government plans propose a single type of house for all 9714 families. The only variation is that the same houses will be on stilts in Car Nicobar. The reconstruction programme guided by the Indian Planning Commission and Empowered Group of Ministers has been entrusted to central and local government agencies (CPWD and APWD) and NGOs. All the houses are to be built as per the design, specifications and technology finalized by CPWD whether being constructed by CPWD (7889 units), by APWD (1066) or NGOs (759).

The houses have been planned as twin units like government quarters two homes together with a dividing wall rather than free standing. The communities however, say that such houses do not meet their needs. Traditional houses vary for tribal families and non tribal families, for agriculturist families and fisher families, from one island to the other island, depending on their lifestyle, occupation, customs, local resources and skills. The ecological significance of Andaman and Nicobar Islands need not be reiterated here. In such fragile ecosystem, houses are being built with reinforced cement concrete (RCC) isolated footings, steel structures, corrugated galvanized iron sheets (CGI), bamboo boards and aero-con blocks, all imported from mainland India. These are projected to be alternative eco-friendly materials. But, the prototypes based on these materials were rejected by the community. The only significant change the Government made was that aero-con panels on the external face were replaced with timber planks. However, final specifications are not reflected in any model on the islands and are shown only in a model erected at the Chennai office of CPWD. Communities on the islands have been using timber structure houses which they know how to maintain, repair and extend as per their needs. Extensions that are securely connected to the new house would be difficult due to incompatibility between proposed structures and the traditional way of building.

The learning in all past disasters has been to involve the communities in reconstruction work to achieve any satisfactory level of recovery. This has been disregarded in favour of construction through large contractor companies. A & N communities feel that reconstruction could have provided them opportunities for local employment, particularly for the carpenters and other highly skilled builders amongst them, but all this work has been awarded to contractors. Information is the first pre-requisite for any effective participation but communities have little information about their inclusion in the programme, location of the settlements, their own plots, house designs, materials that are being used or the roles and responsibilities of contractors and implementing agencies. Effective community participation needs to be planned through the whole process of design, procurement, implementation, monitoring and supervision. (Anil Kumar S, Shikha S, 2007)

3.2 Participation of the affected community

Despondently community involvement was limited to only a few consultations at the design stage. The ineffectiveness and inadequacy of these consultations is reflected in the fact that only one type of design is being built for 9714 families across eleven different islands. Clearly, the prefabricated steel structure houses with RCC footings have been conceived more on the basis of capacities of delivery agencies rather than community needs and priorities. The author finds out these remarks from the disaster survivors who now relocated in the various places of the Andaman such as Bambooflat, Manpur etc.

Another crucial point was the location of the affected communities have no information about the propose site, location or specific plots for their new homes. Though few people have seen the prototype houses built by the Government, they have rejected it. The final design, materials and specifications is not known to them. Non-tribal communities have rejected the house because it does not suit the location for their agriculture or fishing activities. Tribal communities in locations like Harminder Bay have also made it clear that any location other than where they presently stay is not acceptable. All families are being relocated on the land identified by the Government officials.

3.3 Relocation

Many families will be relocated on some different islands now. After the discussions with communities across the islands, it was noticed that a large number of houses are going to remain vacant and unoccupied. At Loknath Pahar and Namunaghar in South Andaman and Machhidera, Netajinagar and Harminder Bay at Little Andaman, agriculturists, fishers and tribal community were not keen to move to any of the proposed relocation sites. The place of residence has always very critical linkages with their livelihoods. It is very likely that the tribal community will build its own traditional houses using their own traditional materials procured from the forests at a later stage though they will wait to ensure their entitlement from the Government.

3.4 Land rights

Use of land around the home is crucial to securing the housing rights of tsunami Survivors but it is not clear whether the affected families will be provided any ownership to the homestead plot. Though some local government officials that it could not be allowed, the higher level A & N officials in Port Blair said the policy in this regard is still being worked out. The future growth of the house is critical in the local context as the house being provided is only basic essential space and not sufficient for the families, particularly when the family size grows with time. Peoples perspective In a nutshell, the communities we spoke with are not in favour of the declared reconstruction programme but feel vulnerable due to dependence on the Government and many feel unable to voice their concerns. People prefer the traditional house design and materials and would have preferred if cash or material support was provided. They would have built a larger-sized house of their own choice in a lesser amount. But the present construction plan does not allow that. (Vivek R, Rajendra D, & Dharmesh J. 2006).

However, the extent and quality of participation and acceptance of the housing designs by the local communities is questionable. One of the most important things that has emerged in discussions with the communities is that livelihood. The complexities of the post-tsunami recommendations reconstruction situation are quite clear. There is no clear policy framework and instead, merely a reconstruction project has been formulated. CPWD is steering the implementation under the patronage of MoUD and has already awarded contracts to two big corporate companies. APWD and NGOs are also implementing small number of houses as per CPWD directives. One type of design is being built for all types of the communities, irrespective of their occupation and lifestyle. The proposed cost of each house is estimated to be Rs 6.5 lakh in South Andaman to Rs10 lakh in Car Nicobar and Rs.12.5 lakh in Nancowry. There is a huge gap in information with the community about how, why and what decisions have been taken. Finally, it is very clear that the current framework of the reconstruction programme is not people-friendly and raises serious issues. Following recommendations are made by the different expert review team to ensure adequate and dignified housing to the tsunami affected communities. District Administration is wholly responsible for the formulation of District Disaster Management Plan and relief & rehabilitation in case of any disaster in North & Middle Andaman District. The Andaman and Nicobar Islands Administration has set up a Disaster Management Authority (DMA) under the chairmanship the of the Union Territory (UT) Lt Governor Bhopinder Singh as part of the Disaster Management Act, 2005.

4 Recent disaster profile (Andaman & Nicobar islands)

The frequent incidence of the various disasters especially earthquake, flood and climate related disasters are much experienced by the islanders. All these calamities largely affect the normal life of the islanders and the efforts made by the administration is not up to the mark to meet the immediate and long term requirements of the society. Some of the following shows the occurrence and severity of the disaster which is happening on a regular basis to make difficult the life of the islanders. (Rajeev M M *et al.*, Amrita SREE, 2009). The Ross Island, close to the Port Blair harbor, is highly prone to the disasters such as earthquakes, landslide and tsunami.

Moderate 5.6 quake hits off India's Andamans, 2011-01-01 20:10:00: A moderate 5.6-magnitude earthquake struck off the coast of India's Andaman Islands Tuesday, the US Geological Survey said, but there were no immediate reports of damage or tsunami warnings issued. The undersea quake hit at a depth of 25 kilometres around 192 kms southeast of Port Blair on the Andaman islands, which are located in the Bay of Bengal, at 19:39 pm local time (1339 GMT), the USGS said.

Chennai, June 13, 2010 Earthquake hits Andaman, tsunami alert sounded: A massive earthquake measuring 7.7 on the Richter scale struck the Andaman and Nicobar Islands on Sunday at 00.56 am with epicenter at 160 km west of Nicobar Islands at the depth of 35 km. The Hyderabad-based Indian National Centre for Ocean Information Services (INCOIS) issued a 'Tsunami watch' notice soon after the quake.

Earthquake hits Andaman, Orissa, Port Blair/Bhubaneshwar, March 31, 2010: An earthquake measuring 6.9 on the Richter scale shook parts of Andaman and Nicobar Islands on Tuesday night leaving two persons injured but there was no report of any death or damage. The quake, which measured 6.8 on the Richter scale in Bhubaneshwar, jolted coastal areas of Orissa, bringing panic-stricken people in some areas out of their houses. "The epicenter of the earthquake was located at Landfall Island, 240 km north of Port Blair. The earthquake shook parts of Andaman Islands but no tsunami alert was sounded", Deputy Commissioner of South Andaman S N Jha told PTI.

Earthquakes strike Andaman, Tokyo Tue, Aug 11, 2009 10:30:37 IST: An earthquake measuring 7.6 on the Richter scale struck off the coast of the Andaman Islands at 1:55 am (local time) on Tuesday morning. Ten minutes later an earthquake measuring 6.4 on the Richter scale struck the Japanese capital, Tokyo. On June 27th, 2008, Andaman is hit with sets of tremors measuring 6.7 and 6.1 on the Richter scale. The earthquake hit the region at around 5:11 pm and 6:39 pm respectively.

5 Recommendations

Looking into the above critical community concerns and facts, the following recommendations are derived out to accomplish the needs of the disaster survivors in the islands.

Policy framework: A comprehensive policy framework is needed that clearly articulates objectives, eligibility criteria and entitlements of the affected families and lays guidelines for processes for selection of construction sites and execution of construction. It should also define the roles and responsibilities of the different agencies and stakeholders involved and outline the principals of community participation, the time frame and the grievance redressal mechanisms.

Transparency on entitlements: The list of families entitled to new homes should be shared, along with the eligibility criteria. A mechanism should be put in place to ensure inclusion of all families that qualify, irrespective of where they are staying temporarily.

Suitable location: The site should be finalised only after informed community consultations and agreement. Plot allotment should be immediately taken up to facilitate community inputs to their own houses. Knowing ones own plot is an essential prerequisite for participation.

Information: All relevant information house design, construction materials, cost, and the responsibilities of the administration and other agencies such as CPWD, APWD or contractors must be communicated to the people, along with periodic reports on progress and decisions. An Information dissemination mechanism should be established and it should ensure that information reaches to people in their temporary settlements or other locations where they are staying. It should be in a format that people can understand.

Womens property rights: The ownership title to homestead plot must be given to the family in the joint names of wife and husband and in particular cases, to the woman only.

Housing modifications: One design cannot fit all. Permits for extensions and modifications of the house should be given to the titleholder/s. House owner(s) should be empowered to make those changes at the time of design construction.

Monitoring construction: Community must be empowered with specifications of materials and construction details so that they can monitor these. A formal mechanism must be established for monitoring quality and progress of construction which can provide periodic feedback to implementing authorities and convey the subsequent actions to the community.

Promoting local building practices: People should be given an option to build on their own as per their needs at appropriate locations of their preference. The process should be facilitated by providing financial and material assistance. The traditional materials and technologies that Communities have expressed a preference for should be promoted in the reconstruction plan. The traditional structures that people have been building performed well during earthquakes.

Environmental protection: Assessment should be made to understand the environmental impact of large construction contracts. There needs to be constant watch on various construction processes, particularly sand mining from the beaches, etc.

Decentralized basic services: The post-tsunami reconstruction plan envisages construction of 'centralized drinking water and sewage disposal schemes'. Such systems should not be implemented, particularly as current dependence on external agencies to run such services is expensive and unreliable. Instead, a decentralized system should be promoted that engages communities, is eco-friendly and encourages responsible behaviour of service users. The traditional structures that people have been building performed well during the earthquake.

6 Conclusion

The post disaster recovery and reconstruction is considered one of the very important dimensions in the disaster and emergency management programmes. This will be effectively carried out through the effective network and participation with the affected community and the government to address the immediate and long term needs of the community. All the past disasters are proved that the effectiveness of the both mechanisms are very critical and the need of the hour. More pre- disaster planning and mitigation efforts are fundamental than working on the post disaster situations. Large amount of resources and support services from the hands of all humanitarian actors are required to address the disasters and its allied issues and concerns of the affected people who really deserved the

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A study on the role of self help groups in communicating risk and risk management strategies for community resilience and security in Tamilnadu, India

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ABSTRACT

Natural Disasters like Cyclone, Flood and Tsunami have been affecting the coastal communities for a long time. The prime reason behind this impact is the lack of last mile communications. In a disaster situation, timely warnings allow people to take actions that save lives, reduce damage to property and minimize human suffering. To facilitate an effective warning system, there is a major need for better coordination among the early warning providers as well as those handling logistics and raising awareness about disaster preparedness, security and management. There are many new communication technologies that allow warning providers not only to reach the people at risk but also to personalize their warning message to a particular situation. Opportunities are available right now to significantly reduce loss of life and properties if disaster warning systems can be improved. In this study, the researcher analyzes how different communication strategies play an important role in disseminating information among the people during emergencies using survey and interviews. This paper also looks into the effective role of media in communicating risk management strategies to coastal community through self help group women in the Tamil Nadu state of India.

1 Introduction

India is the seventh-largest country by geographical area, the second-most populous country, and the most populous democracy in the world. India is also prone to natural disasters. It has only 2.4% of the world's surface but an incredible 16.7% of the world's population (MIB, 2009). India has greater and increasing vulnerability to the socio-economic impacts of extreme weather events (floods, droughts, cyclones, and hail storm, thunderstorm, heat and cold waves) due to large population growth, and mitigation into urban areas. Fishing has been the primary occupation in these costal areas. While these fisherfolk know the art of living, majority of them are economically and educationally far backward and are struggling to survive even after more than half a century of independence. The fishermen lived exclusively in isolated hamlets near the sea shore, river banks, ponds and lakes without any sort of the social contacts with the civilization. As such they are not assimilated in the general social order.

Most of the fisher folks are uneducated and they were not aware of their vulnerability to natural disasters. The Indian Ocean Tsunami in 2004 had resulted in huge loss of lives along the Indian coast. Lack of awareness and preparedness was the main reason for such a disastrous impact. The epidemic diseases expected to spread aftermath a disastrous event is also unknown in their areas. The fisher-folk live in an unhealthy environment and they have no knowledge about sanitation, personal hygiene and measures to be taken for protecting themselves from epidemic diseases.

2 Objectives of the study

- To analyze the knowledge level of fisher folks with respect to natural disasters and health related issues aftermath a disaster.
- To produce disaster preparedness and health communication messages in audio and video formats.
- To find the effectiveness of media as communication tools for disaster preparedness and health communication among self help groups in a coastal village of Tamilnadu.

For performing this research, an experimental method was adopted with Questionnaire as the tool for data collection. The Questionnaire is prepared in the local language *Tamil*. It consisted of 23 questions in total covering the demographic profile, socio-economic profile, media profile and few questions to find the effectiveness of media for communicating disaster preparedness and health information. Purposive sampling method was used to select the respondents. The total number of samples collected is 50 and the study was conducted in Uyyalikuppam, a tsunami affected village in Kanchipuram district of Tamilnadu in India.

The samples were Self Help Group (SHG) women. SHGs among fisher-folk community are successful and they work in a pattern wherein the leader conveys the messages to other members of the group. Creating disaster and health awareness among these Self help group women will benefit many fisher-families.

The study area Uyyalikuppam is a fisher community village in Kanchipuram district of Tamilnadu in India. Uyyalikuppam was worst affected by recent tsunami in 2004 and by other coastal disasters such as cyclone and flood every year. Aftermath the seasonal disasters, the area is contaminated to a greater extent. Because of this contamination, diseases are found to spread increasingly. Hence there is a vital need to create awareness among the fisher-folk on disaster preparedness/personal hygiene and sanitation/cleanliness/solid waste management etc. There were 25 self help women groups in Uyyalikuppam. Two members in each group are selected and a total of 50 self help group women participated in the study.

The convenient date and timings of the respondents were taken into account for fixing up the study. All the self-help group women (50 Nos) gathered at the community hall of the village panchayat. Initially, pre-test was done (using questionnaire) with the respondents. The research assistants helped the respondents who found difficult to fill the questionnaire. Then the respondents were introduced to the media tools which were in audio and video formats. The content covered in the communication tools were natural disasters; disaster preparedness; prevention of epidemic diseases during post-disaster scenario; general helath and hygiene; etc. After the introduction of media tools, the post-test questionnaire was given to them and data was collected. The percentage analysis, involving coding, tabulating and counting were used in order to analyze and interpret the data collected from the study conducted.

3 Analysis and interpretation

3.1 Coding for analysis

The analysis of the Pre study indicates that the highest level of education among the entire population is 10th Std. The average no. of adults in a single family ranges from 1–7 and the average no. of Children in a single family ranges from 1–5. It is also known that the nature of job done by most of the population is household work, some are working for daily wages and the rest and maximum are fisher-women. The Pretest also indicated that all the respondents in the sample know what the coastal disasters were, since they are worst affected by Tsunami.

The Pretest also dealt with the preparedness level of the population in facing the Disasters. 0% of the population is very well prepared for the disaster, 76% are better prepared and 24% are still unprepared for facing any type of disaster. About 32% of the population is informed about the various disaster preparedness measures through NGOs, Family, Friends, Teacher, School and Television and the rest 68% are not informed about these preparedness measures. With respect to the volunteers who helped during disasters, 64% of them where a member of SHGs and rest were not.

Intended questions were also based on some basic health messages with respect to Personal hygiene, Sanitation and Epidemic diseases. These questions were helpful in analyzing the recall value of the respondents which was very well and most of the women could recall and answer correctly.

Questions were asked about the importance of cleanliness, awareness on the type of wastes and their disposal, on construction & cleanliness of toilets, about the need for Personal Hygiene - Wash Hands before eating, ill-effects of growing nails, how to sneeze in public places, about the spread of epidemic disease after disaster, to point out one water-borne disease from options given and the preventive measure for dysentery.

For comparing the pre- and post-test scores, the questions with the right answers were only taken into account and coded. The pretest is coded as X and the post test value is coded as Y. The treatment effect of the media is marked as T. The comparison table is given below.

3.2 Cleanliness

Questions	Pre-Test (X)	Post-Test (Y)	Effect (T = Y − X)
Importance of cleanliness	48%	94%	46%
Causes of environmental degradation	36%	88%	52%
Awareness on the type of Wastes and their disposal	32%	92%	60%
Construction & cleanliness of toilets	34%	88%	54%

Effectiveness of the communication tool on sanitation can be found out by the difference in the results in datas of Post-Test and Pre-Tests.

3.3 Personal hygiene

Questions	Pre-Test (X)	Post-Test (Y)	Effect (T = Y − X)
Need for personal hygiene Wash hands before eating	60%	96%	36%
Need for personal hygiene Ill-effects of growling nails	40%	96%	56%
Need for personal hygiene How will you Sneeze	44%	84%	40%
Need for personal hygiene Brushing	16%	44%	28%
Need for personal hygiene Spiting in public places	36%	82%	46%
Need for personal hygiene Cold preventive measures	12%	84%	72%

3.4 Epidemic diseases

Questions	Pre-Test (pr)	Post-Test (po)	Effect (po−pr)
Coastal disasters known to you	100%	100%	—
Will epidemic diseases spread after a disaster	12%	86%	74%
Measures to prevent epidemic diseases	24%	96%	72%
Water borne diseases	28%	94%	66%
How dysentery can be prevented?	12%	78%	66%

Even though, more than half of the respondents were unaware of the importance of cleanliness, media played a major role in acting as a communication tool to create health awareness among the fisher folks. The 94% result in the post test proves it. 54% increase was there in the understanding level of the respondents about the causes of environmental degradation, through media communication tools. 32% of respondents only were aware about the type of wastes, but once they were taught about it using media, 92% understood the importance of waste disposal and promised to segregate the wastes in future. 54% increase was found in the understanding level of respondents on the importance of construction and cleanliness of toilets. 40% increase was there in the understanding level of the respondents about the importance of washing hands before eating through media communication tools. 56% increase in awareness was found in respondents on the ill-effects of growing nails. Before the communication tool was introduced to the fisher folks, 64% of the people used to spit in public places. After the introduction of the communication tool 82% of the respondents have learned not to spit in public places. 12% of respondents only were aware about the Cold preventive measures, but once they were taught about it using media, 72% increase in awareness was found among respondents. Only 12% of the respondents are aware that epidemic diseases will spread after a disaster. After the introduction of the communication tool, the awareness level increases to 86%. Only 24% of the respondents know the measures to prevent epidemic diseases, after being introduced to the communication tools there was 72% increase in awareness. 28% of the respondents know the difference between water borne diseases and Vector borne diseases. After the post test, 94% of the respondents know the difference between them. 66% increase was there in the awareness level of the respondents about the preventive measures of dysentery through media communication tools.

4 Findings and conclusion

More than half of the respondents were not aware about the importance of cleanliness. Once they were introduced to the communication tool, the awareness level increased. There was a major increase in the understanding level of the respondents about the causes of environmental degradation, through media communication tools. Majority of respondents were not aware about the type of wastes, but once they were taught about it using media, Most of them understood the importance of waste disposal and promised to segregate the wastes in future. Minimal percentage of the respondents was aware that epidemic diseases will spread after a disaster. After the introduction of the communication tool, the awareness level increases drastically. The respondents dont know the difference between water borne diseases and Vector borne diseases. After the post test, majority of the respondents understood the difference between them. Hence, from this experimental study on the effectiveness of disaster and health communication among self help group women of fishermen community, the researcher concludes that media can play a vital role in creating health awareness among fishermen community. Audio and Video Communication tools were found to be very effective for creating health awareness. When a message is conveyed in the form of folk songs or in the form of drama, it has a good reach when compared with the plain explanation of disaster and health messages. A great difference is found in a common man conveying a health awareness message and a celebrity conveying a health awareness message. The latter had a great reach as it is from a popular celebrity.

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Development and field evaluation of basic life support system tools in community disaster preparedness

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ABSTRACT

Background: Many of the public has poor first Aid and health literacy. A First Aid training course was developed in order to improve this. This paper describes the training course and reports an evaluation study looking at changes in knowledge, attitudes and help provided to others. Methods: The study was conducted in Allapad at Kollam district, Kerala and data was collected from the 30 participants of the local communities. Evaluation questionnaires were given at before and after the training programme. Results: The course improved participant's ability about life saving skills, awareness of first aid and Increased confidence in providing help to someone in critical situations. Conclusions: First Aid training appears to be an effective method to improving health literacy, which can be widely applied.

1 Introduction

Disasters have existed ever since the existence of the mankind. The focus of nature has been relentlessly violent and Natural Disasters have been called the greatest destroyer of lives and property (Rao, 2010). Disaster management is a continuous process that covers many important aspects ultimately leading to reduction of vulnerability and susceptibity of region and society from natural hazard (Schneid *et al.*2000). The disaster management encompasses the complete realm of activities and situations that occur pre-disaster, disaster and post disaster phase. A successful disaster management planning encompasses the complete realm of activities and situations that occur before, during and after the disasters. Prepared ness, mitigation, disaster, emergency, rehabilitation and reconstruction are in fact cyclical and they overlap, referring to disaster management cycle (Sharma K.V 2004).

Disaster preparedness is essential to all citizens, communities and disaster relief organizations whether state, federal or community based. With the effects of recent natural disasters such as the Indian ocean tsunami in 2004, Hurricane Katrina or the atrocious tornado season of 2006 in the Midwest, all of these situations were handled by utilizing a structured and thought out disaster preparedness plan understanding the short and long term affects of such disaster situations.

An emergency management plan can consist of written directions on how to shut off or turn on water, gas and electricity if advised by medical and or disaster relief personnel. All parties should know how to reach emergency personnel in their area for medical treatment, police assistance and/or advice on what to do during a natural disaster such as a tornado, hurricane or earthquake (Furbee *et al.*2006).

Preparedness is effective through community participation. Preparedness is two phase, predisaster and postdisaster preparedness. Preparedness attempts to inform the public about what they can do before a disaster happens and postdisaster preparedness means informed public how to react in the midst of and aftermath of a hazard event. This type of preparedness to empower the public to provide first-response service to their families, friends, neighbors and themselves. In recent years, disaster managers have established more effective way to increase public knowledge of disaster preparedness and response activities and to get the public to act upon that knowledge(Coppola,2006).

1.1 Disaster and communities

The communities are the first responders in a disaster situation(Policy on disaster management). Community awareness in term of both short term and long term disaster management plans and Community-based disaster management is a risk reduction measure. Proper training programmers can ensure efficient community participation in specific disaster mitigation and preparedness (Sinha,2006). A prepared public must be given the skill that allow them to perform specialized action such as search rescue, first aid or fire suppression (Coppola,2006). First aid is one of the key steps in disaster management, because it is a systematic way to avoid casualties of both the responders on the scene and the victims themselves. (Yodmani,2001). Disaster was related to a higher prevalence of medically unexplained physical symptom, particularly Injury, bleeding, shock, cardiac disorder, burns, and poisoning (Escobar etal.,1992.) First aid training is of particular importance in case of catastrophe, when medical and hospital service are limited or delayed. First aid training is of value in both preventing and treating sudden illness or accidental injury and in caring for large number of persons caught in a natural disaster(Jain,2009).

2 Methodology

The present study was conducted in Alappad Panchayath (9°6^{I}N and 76°28^{1}E) Alappad is a coastal village in the Kollam District of the Indian state Kerala. Geographically the whole of the coastal region of Kollam district is a disaster prone area. The study area was lying between the Arabian Sea and the TS (Trivandrum–Shoranur) Canal stretching 14 kms length and width 50-300 meters. The major threat of Alappad panchayath are Flood, Sea erosion, Tsunami etc. Portion of the panchayath were partially damaged during the 2004 tsunami. Allapad was the worst affected village in Kerala, the "death toll" in Kerala was officially reported as 196 persons in that most of them from the Allapad panchayath this include 148 lives lost, 2194 houses completely destroyed.

Field visit have been done in Alappad panchayath especially along the most vulnerable area in Vellanathuruth. Collecting information through question survey and interacting with local people. Two survey were done with the local people of Vellnathuruth, 30 people were selected from fisher flock community. The first survey was (pre-training survey) conducted before training programme. The questions include experiences in any disaster situations , awareness and capability of life saving skills etc. Another survey conduced (post-training survey) the aim of this survey is to take feed back of first aid training.

2.1 First-aid training and practices

The training programme have been done in Vellanthuruth of Alappad panchayath by 30 people were attended. Training include Emergency, Cardio Pulmonary resuscitation (CPR) training, Relief from Choking and disaster preparedness.

Table 1. Results of statistical analysis.

Parameters	Variable 1	Variable 2
Mean	8.6	21.7
Variance	60.71	30.23
Observations	10	10
Pearson Correlation	0.53	
Hypothesized Mean Difference	0	
df	9	
t Stat	−6.12	
P(T≤t) one-tail	0.00	
t Critical one-tail	1.83	
P(T ≤t) two-tail	0.00	
t Critical two-tail	2.26	

3 Result and discussion

First aid is one of the possible key tool in people living in the area are always at risk. In the present study, the effectiveness of a BLS tool has been tried to be evaluated. Study has been compartmentalized in to two phases, namely, pre-training phase and feed back phase. There were 30 people taken as sample size of which 13 were males and 17 were females. The first section included a questionnaire survey to check the awareness of first aid and its importance. The survey revealed that 27 individuals have some knowledge about first aid. But the training in first aid as part of the study changed the situation- almost all participants became aware of the tools indulged in the raining program.

The participants included the first Aid training were in different age group and based on this the participants were classified in to four age groups:- 10 to 20, 21–30, 31–40 and 41–50. The Comparison between pre-and post training results of performing CPR shows that 73% of the participants are capable to do CPR and gave the feed back that their life saving skills have sharpened.

Certain statistical analysis were also carried out, the results shows that, Mean of all parameters was increased around by three times. The result of variance reduced to half of the previous value, which indicates the hetrogenicity of the local community get reduced by the training. T test shows a significant improvement in the sum at 1% level of significant in the training is effective. Since the Correlation coefficient in 0.53, the correlation in the awareness after training is positively increased and gradual improvement of awareness was identified. So we can inform that the training programme was effective to improve the life saving skill. Awareness significantly and to reduce the heterogeneity among the local people.

4 Conclusion

Training programs and projects implemented in the disaster affected or prone area without considering the need of the society will not accomplish the expected results. Imparting the disaster management lessons to the general public is found to be difficult, as it does not receive its due seriousness among the community. Basic life support system tools are an excellent window to enter into a community and the dissemination of the modules of disaster management. The present study attempted to develop and execute a sound disaster management module to a tsunami-affected community. The introduction of the basic life support tools through participatory practical sessions have really made influences among the community. The results of the study and feedback from the participants show that the developed basic life support and disaster management content received great appreciation and the training has achieved its expected result.

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Towards sustainable flood mitigation strategies: A case study of Bangladesh

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ABSTRACT

This paper outlines a part of a research and design project based on work undertaken for the B.Arch. at the Department of Architecture, Bangladesh University of Engineering & Technology in 2008. This study intended to ease the lifestyle & livelihood of rural dwellers beside the river bank areas in respond to natural hazards like floods. Floods in the deltaic valley of Bangladesh is not merely an environmental issue, they play with the very fate of the nation, not to speak havoc they wreak on the economy of these inhabitants beside the bank side areas. Again this climatologic phenomenon not only poses enormous threats to the locality but also moderate floods contribute to the fertility of the land. Flood hazards of bank side areas of rivers are difficult to control through structural measures; Flood proofing through assistance to self help measures to reduce the damage to property and stress are largely accepted preventive efforts that these people have practiced. This paper focuses on formulating future action plans and some immediate incentives to improve the physical environment that are better suited to the people of river bank areas with frequently changing context. To develop a self-sustain community and sustainable mitigation strategies in response to observed or expected changes in climatic stimuli beside the riverbank areas, study goes through the geo-morphological & hydrological analysis and vulnerability assessments in this area. Finally goal is to provide zoning guidelines & few planning solutions along with modified house building techniques through flood level predictions, which would help the peasants at the time of emergency & could be intergrated into official flood management measure.

1 Introduction

1.1 Background to flooding in Bangladesh

The South-Asian country of Bangladesh, flood is the most frequent natural hazard and is considered to be the main threat. Approximately 60 per cent of the country's land mass is less than six meters above the mean sea level (USAID, 1988; GOB, 1992) and floodwater inundates around 20.5 per cent of the country (3.03 million hectares) every year (Chowdhury, 2000; Mirza *et al.*2001). Only the abnormal floods, the high magnitude events that cause widespread damage are the major environmental concerns facing Bangladesh. In extreme cases it may cover 70 per cent of the country (Mirza, 2002) and the severity of floods and other natural disasters has been increasing in Bangladesh due to climate change. Once every ten years roughly one third of the country gets severely affected by floods, while in catastrophic years such as 1988, 1998 and 2004 more than 60 percent of the country is inundated, that is an area of approximately one hundred thousand square kilometers for duration of nearly three months (CEGIS, 2002). As the majority of the people live in the countryside, their livelihoods are directly or indirectly dependent on the land (BBS, 2003). Therefore, flooding jeopardizes the lives and livelihoods of people. Thus main victims of flood disasters are the poor rural people who are 80 percent (2010) of total population have very little capacity to cope with the losses (theindependent-bd.com). Due to limited resources, floods periodically claim many thousands of lives in Bangladesh disrupt normal economic activities and aggravate already-severe problems of poverty, health and quality of life.

According to Chow (1956), a flood is a relatively high stage of a river that overtakes the natural channel provided for its flow and Ward (1978) defines it as a body of water that rises to overflow land which is not normally submerged. Floods in the Bangladesh are a complex phenomenon (Brammer, 1990). Normal floods are seen as a blessing because they bring economic and environmental benefits (Blaikie *et al.*1994; Handmer *et al.*1999) whereas high floods are viewed as disastrous (Paul, 1997). For example, normal flooding makes arable land fertile and leads to an augmentation of agricultural production (Brammer, 1990) while high magnitude events inundate large areas causing widespread damage to crops, human beings, livestock and property as well as devastation to life and livelihoods (Paul, 1997; Few, 2003). Four types of food are generally recognized in Bangladesh: (1) tidal food; coastal area flooding by tidal and storm surges, (2) rainfall food; excessive rainfall with high stage in outfall rivers, (3) river food; overbank fooding caused by river discharges, and (4) fash food; a sharp rise followed by a relatively rapid recession in the northeastern and eastern hill basin of Bangladesh (Rahman, 1996). Among these four types of floods that occur in Bangladesh, monsoon floods from major rivers cause by far the most extensive damage (Reaviil & Rahman 1995). Thus the rural people & households close to a riverbank those are more susceptible to flooding and erosion, increasing their vulnerability and reducing their ability to cope through time. It is true that frequent losses of their houses & immense sufferings, people in remote rural areas beside the riverbank are living with this flood disaster from the very beginning almost without any positive supports from external society.

Traditionally, the mitigation of flood disaster risks in Bangladesh has focused on infrastructural engineering measures, such as embankments, and ex-post flood relief measures. Since embankments do not offer full protection against floods in Bangladesh, they often create a false sense of security in that populations at risk tend to take less precautionary measures to adjust to floods. Thus a large-scale structural approach has been widely criticized not only in terms of engineering & economic feasibility and social & environmental complexities but also because of leading towards more frequent & abnormal floods. So increasing attention has been turned towards less expensive non-structural measures, which would be suitable for the rural people of the developing countries like Bangladesh. Aim of this research was to determine effective flood risk management strategies in partnership with floodplain populations, taking cultural, social and physical constraints into account and to enable floodplain populations to be aware of flood risks, thus reducing their vulnerability to flooding.

1.2 Objective of the research

Bangladesh, one of the world's most flood prone countries where conventional flood control strategies tend to be based on holistic structural engineering approaches, such as the construction of large scale embankments, diversion canals and dams. This article argues that more emphasis should be given to sustainable non-structural measures focusing on local inundation patterns & other hydro-morphological characteristics. Finally these case sensitive approaches can be integrated into establishing official flood management measures to effectively manage flood disasters in flood prone areas to reduce flood losses.

1.3 Study area & methodology

The study was conducted at the bank areas of Padma river. It is the lowermost reach of the Ganges downstream from the Farakka Barrage to the confluence with the upper Meghna. Padma river can be devided into two distinct reaches, which are hydrologically quite different from each oyher. Flooding is sudden and rapid because of the rise of the water level during the rainy season and breaching of the riverside embankment. Running water from the Padma river along with monsoon rainfall covers the land beside the bank areas at a great speed and hence people lack time to evacuate with their belongings.

A case study carried out in one of the most flood prone localities of Bangladesh, focusing on household and community vulnerabilities beside the Padma river bank areas. Physical survey conducted through random sampling procedure to select 28 households along the riverbank areas. Primary data were collected through photographic survey, interviews as well as via focus group discussions with household members. Intensive literature survey has conducted to identify most relevant and useful strategies related to reducing the vulnerability of rural communities to floods.

From the field survey, it reveals that, households with lower income and less access to productive natural assets face higher exposure to risk of flooding. Regarding the identification of coping mechanisms & mitigation strategies to deal with flood events, we look at both the beforehand household level preparedness for flood events and the afterward availability of community level support and disaster relief.

2 Theoretical perspective

2.1 Vulnerability to flooding

To conduct this analysis, this paper approaches the issue of disaster like seasonal flood from the point of view of vulnerability. The term vulnerability refers to the exposure of a group or individual to stress due to social and environmental change, while stress is as unanticipated change in and disruption to livelihoods (Adger, 1999). A number of different factors, such as flood characteristics, physical infrastructure, geographic location n, geomorphological setting and people's cultural, political and socioeconomic condition (AlcántaraAyala, 2002;

Few, 2003; Hutton & Haque 2004), condition vulnerability to flooding. Generally, vulnerability is seen as the outcome of a mixture of environmental, social, cultural, institutional and economic structures and processes related to poverty and (health) risk, not a phenomenon related to environmental risk only. Besides risk exposure, adaptive capacity is seen as a key component of the concept of vulnerability (Adger 2000; IPCC 2001).

2.2 Flood mitigation: A review of structural & nonstructural measures

Natural hazards like flood need not become a disaster, if it has planned mitigation guidelines & awareness among the locality of how to deal with them. This would reduce the losses of life and minimize human suffering. There are two different ways to mitigate floods, one is structural and the other is non-structural measures.

2.2.1 Structural flood control measures & outcome

Structural measures are in the nature of physical measures and help in "modifying the floods". Aim is to keep water away from people. In response to the devastating impacts of the 1988 flooding disaster, the Government of Bangladesh, in cooperation with several bilateral donors and international agencies, decided to the formulate a massive flood action plan (FAP) (World Bank 1990). Their aims were at the implementation of systematic measures to control or significantly reduce the adverse impacts of future floods, with an emphasis on structural engineering solutions. Although the FAP proposed a series of complementary measures, such as a disaster preparedness program, the development of early warning systems, it was mainly focused on canalization, embankment and compartmentalization as the underlying foundations of a comprehensive flood control strategy. Increased accumulation of sediment and silt that cannot be deposited on flood plains (because of the embankments) cause river beds to rise, and, thus, may lead to more frequent floods and even the topping of embankments during abnormal floods (Chowdhury 1992). There is evidence that average flood losses inside flood control projects were actually greater than in unprotected flood areas (Thompson & Sultana 1996). This large-scale flood control projects, FAP was initially seen as a top-down initiative with a clear lack of consultation with the affected population.

2.2.2 Nonstructural flood control measures & outcome

Non-structural measures are in the nature of planning and help in "modifying the losses due to floods". This tries to keep the people away from water. These non-structural measures can be either short term or long term like flood plain zoning & flood forecasting & warning.

Non-structural approaches to flood mitigation include adaptive actions taken by affected communities, either individually or collectively, and by local and national government agencies before, during and after the floods (Paul 1997). Most of the measures resorted to by affected communities are of a preventive or corrective nature in that they are intended to minimize damage caused by floods. Some of these adjustments are related to material responses at the individual level; others are related to social organization or relationships. Selling land, livestock and personal belongings; borrowing from friends, relatives or microcredit organizations; and spending previous savings are the most popular non-structural measures used by lower income urban and rural dwellers to mitigate loss caused by floods (Haque & Zarnan 1994). ESCAP guidelines also stress that countries with scarce financial resources should give emphasis to 'policies and measures which will steer development away from high risk areas and diminish vulnerability of new investments' (ESCAP & UNNDP 1991). This leads to the conclusion that the development of local social and institutional networks can effectively lessen the impacts of natural disasters such as floods.

Table 1. Margin flood hazard in land beside the Padma riverbank areas. (Source: ISPAN, 1995).

Percentage of land floods (1989–1992)	**Duration of flood (1989-1992)**
45%	18%
71%	31%
56%	32%

3 Flood events & its consequences in case studied area

The people beside the Padma riverbank areas are vulnerable to various natural hazards, among them flooding is the most common and occurs with unfailing regularity.

3.1 Flood scenario along the Padma river

The wandering Padma river showed a clear trend of a changing pattern from the north to the south. In 1991 it was observed that 65% and 33% of the areas in the upper and the lower reaches respectively were affected by flood (Table 1). The main reason behind this is the effect of a dampening of the flood peak as it progresses downstream.

3.1.1 The flood depth map analysis along with the inundation level and flood duration map of Padma riverbank areas reveal the severity of flooding scenario in the year of 2004

The most damaging aspect of the floods has been the destruction of peoples' livelihood due to interruption of transportation and communications, submergence of houses, etc. Most developing countries like Bangladesh lack the resources to implement effective policies aimed at better disaster preparedness, prevention and mitigation. Thus every year thousands of houses got flooded along the Padma reach areas (Table 2).

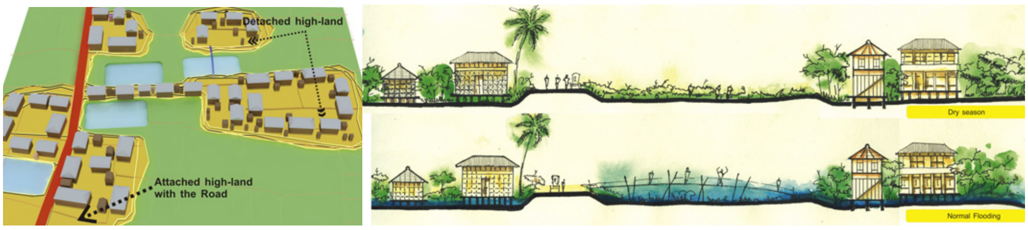

Figure 3. Axonometric view & sections at dry & wet seasons showing typical arrangements of homesteads beside the Padma riverbank areas.

Figure 4. Scatter arrangements of homesteads showing detached highlands & few attached with the main rural road (source: field survey at Hasail-Banuri village at Munshugonj beside the Padma riverbank).

Table 2. Percentage of Houses flooded by year (Source: ISPAN, 1995).

House flooded (1987)	House flooded (1988)	House flooded (1989–1992)
46%	100%	03%
29%	100%	04%
03%	94%	01%
27%	98%	03%

3.1.2 Possible causes

Flood plains along the Padma riverbank areas settlements took place firstly by the riversides, where alluvial soil is ready for the cultivation. But due to subsequent bank erosion peoples have started building their houses not only following the river courses but also in different places with scattered forms to meet the need of scarcity of houses & lands. Sometimes this spreading of settlements ultimately resulted in the developments of different types of fertile land acted as the basic attracting factor for living. So local people hold up their lands, make raised earthen platforms and build their houses. As a result there is less regularity among these houses and the settlement appeared like the scattered form (Figure 4). The scattered arrangement of houses has the disadvantages for transportations and communication during normal flood. And this situation has got worsened during severe flooding at monsoon. At figure 3 (left), one of the detached highlands from 'Hasail-Banuri' village beside the Padma riverbank areas have shown along with sections during dry & wet season (figure 3, right). At normal flooding, low lands got inundated, thus homesteads get detached from the main road.

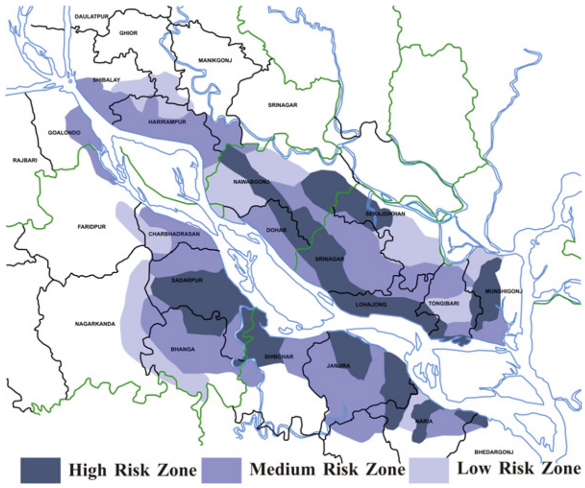

Figure 5. Hazard zoning map for Padma riverbank areas.

4 Recommendations & conclusion

4.1 Solutions for sustainable flood mitigation strategies

Flooding is a natural phenomenon, which cannot be prevented. To mitigate flooding propensity in Bangladesh, both the Government of Bangladesh and the people will have to shift their paradigms, as well as will have to adopt land use planning following localized hazard zoning map following geological suitability & active hydrodynamic processes.

Solutions to flooding problems can be achieved by adopting and exercising watershed-scale best management practices that include: floodplain zoning, restoration of abundant channels and lakes, dredging rivers and streams, increased elevation of roads and village platforms or homesteads, efficient storm sewer systems,

Figure 6. Typical stilt constructions beside the Padma river bank areas & suggestion for stilt height at three hazard zones.

establishing buffer zones along rivers, good governance, indigenous adjustment of life-style and crop patterns, and improvement on flood warning/preparedness systems. Finally Strengthening practically based community level information on how to utilize locally available resources to reduce vulnerability and to mitigate against the impacts of flooding.

4.1.1 Hazard zoning map based on hydrologic suitability

Hazard zoning map will place some restrictions & give some suggestions on the use of land on flood plains, will finally reduce the cost of flood damage. The flood depth that was categorized into three categories (Figure 2) and then these classified flood depths were overlaid onto flood duration map along with Inundation level (elevation height of water during severe flooding) and finally they imposed with geological maps to calculate hazard scores. This process reveals that the flood extent area has significant influence through the flood depth and the flood duration. This hazard zoning map (Figure 5) for Padma reach area has prepared based on estimation of flood images (taken at April, 2004 by Institute of water modeling, Dhaka, Bangladesh) of the flooded area beside the Padma riverbank areas. This hazard zoning map has categorized in three zones grading from highest to lowest flood hazard zone.

Though building on stilts or on a higher platform is a common practice in this flood plain area (Figure 6, Left). But there isn't any appropriate or fixed size of stilt. Based on hazard zoning map and highest flood water level during monsoon, stilt houses have been suggested for these areas with three different stilt height applicable for three hazard zones (Figure 6, Right).

This zoning of flood hazard should be updated after a regular interval based on current hydrological data & local governments may pass laws that prevent uncontrolled building or development on flood plains to limit flood risks and to protect nearby property.

4.2 Conclusion

Flood problem in Bangladesh is not merely a hydraulic dynamic; rather, it is also linked to issues of demography, ecology, education, settlement pattern, society, socioeconomic status and even culture and politics (Haque & Zaman 1993; Kunii *et al.*2002). It is evident that in response to a flood, people adopt different indigenous preventive and mitigative measures or coping strategies. However, the study finds that indigenous coping strategies are highly effective only in a normal flood. Again the economy of Bangladesh cannot depend on structural measures. But feasible non-structural measures like up-to-date case specific hazard zoning map can be enacted at present that have the potential to be particularly effective in mitigating the damaging effects of floods. This study finds that flooding has disastrous impacts on people's socioeconomic condition as well as on the environment & government structural initiations like FAP has failed as a result of its disconnection from the local population (Custers 1993). Therefore an effective settlement planning guidelines have suggested through providing a hazard zoning map for the Padma riverbank areas. A need exists for the integration of site specific hazard zoning map based on current hydrological data into a disaster management framework. People's indigenous knowledge systems and flood mitigating strategies must be complemented by additional inputs from early warning systems followed by external assistance during and after a flood to enhance victims' ability to cope.

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DISASTER, RISK AND VULNERABILITY CONFERENCE 2011
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NATIONAL DISASTER MANAGEMENT AUTHORITY

MINISTRY OF EARTH SCIENCES

DEPARTMENT OF SCIENCE AND TECHNOLOGY

Preface

The Disaster, Risk and Vulnerability Conference 2011 (DRVC2011) (www.disasterresearch.net) started out of the desire to see Disaster Professionals and students coming together from different disciplines and out of the idea that such a gathering of minds from disparate disciplines, but with the common chord of 'disaster' interlinking their interests would throw up interesting insights into this nascent field of study. It is a well-recognized fact that interdisciplinary research is the need of the hour, and this is especially true for the field of Disaster Management (DM). Conferences act as foci for exchanging ideas and for establishing new collaborations. Vibrant discussions make conferences come alive. This compendium of papers from the DRVC2011 shows that the field of DM derives inputs from fields as far-ranging as Artificial Intelligence and Cumulus modelling to Psychology, Social mapping and onto Retrofitting and Structural Mapping. The premier research support and promotion agencies in India like the Department of Science and Technology, Ministry of Earth Sciences and National Disaster Management Authority extended financial support to the conference, and this has helped us immensely in the proper organization of the conference and helped us in bringing out the conference proceedings without delay. The MG University is also thanked for the financial support and infrastructural facilities provided.
The University needs special appreciation for having had the prescience to initiate India's first full-time MSc program in Disaster Management in 2006.

The support we have received from the State Disaster Management Authority is also thanked and we hope this conference will help in establishing strong links between the academia and the Government as represented by the SDMA and ILDM. The IMA DM Cell Kerala deserves our thanks for coming up with the proposal for a session on Emergency Medicine. Similarly the NDRF is thanked for their exhibition and demonstration on disaster equipments. Their quiet confidence and professionalism is reassuring in our times of exponentially increasing natural and man-made disasters. We also thank all our colleagues, students, researchers and staff of the School of Environmental Sciences, as well as of the Advanced Centre of Environmental Studies and Sustainable Development, MG University who took an active interest in the organization of the conference. Prof. A.P.Thomas is thanked for planting the idea of the conference.

Last but not the least, it is you, the discerning participant, who is to be thanked, for your dedication to the cause of learning and research and for taking pains to come over to this southern tip of the Indian subcontinent in pursuit of excellence in Disaster Research.

Kottayam, India
12 March 2011

Dr.A.P.Pradeepkumar
Convenor, DRVC2011

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3D time history analysis of RC structures versus commercial methods with attention to the modeling of floor slabs and near versus far-fault earthquakes

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KEYWORDS

flexural stiffness
floor slab
near-fault earthquake
wall-frame structures

ABSTRACT

Commercial software such as ETABS and SAP, commonly used for the analysis of apartment buildings, assume the slabs as a rigid or semi-rigid membrane and only roughly allow for the slab's flexural stiffness using the concept of effective width. These assumptions when further simplified adopting a 2D frame method that ignores the torsional effects may produce results that are very different to the full 3D finite element modeling in particular when time-history nonlinear dynamic behavior is sought. The errors could be larger in near-fault earthquakes that often excite higher vibration modes. Recent major earthquakes (Northridge 1994, Kobe 1995, Chi-chi 1999 and Bam 2003, etc.) have shown that many near-fault ground motions possess prominent acceleration pulses that result in different structural responses for common medium to high-rise buildings. Incorrect incorporation of the flexural stiffness of slabs can in some cases underestimate the lateral stiffness. It is shown in the current paper that in a wall-frame structure subjected to near-fault earthquakes, the full 3D time history modeling can significantly vary the analysis results and as such is an important consideration in design.

Disaster management knowledge base induction within the education sector of Kerala, India

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KEYWORDS

disaster education
curriculum development
knowledge management

ABSTRACT

India's diverse risks to various natural hazards on account of its unique geo-climatic conditions are quite well known and studied by many researchers from India and abroad. The vulnerability of people to natural disasters depends on their socio-economic status which determines the non-structural components of vulnerability indicators. The socio economic system of a nation has imperative effects in determining the educational stability, coverage and schooling across the country and it alters in states as per the political willingness and institutional strengthens. An education system embedded with disaster management concepts and practices is crucial to reduce the vulnerability of communities and to equip future generations with disaster resiliency. Disaster management educational institutes and authorities can make relevant changes in improving the individuals and community capacity to prepare for, respond to and recover from disasters. Progress in disaster knowledge dissemination in Kerala education sector has been evaluated for the present study with an aim of segregating the disaster management components from different educational hierarchy. Efforts have been put forth to identify the existing gaps in the disaster management education and awareness structure among the students undergoing various curricula and syllabi. The study tried to identify the absence or presence and extent of disaster management components in normal education system in schools as an exclusive subject or as an ingredient in traditional subjects of learning. University level dissemination of disaster management knowledge base through graduate and post graduate courses of both arts and science streams in the universities of Kerala has also been considered to quantitatively assess the student community who acquires methodical disaster knowledge annually.

Dam disasters: Risk assessment, avoidance and control during the planning, construction and stewardship phases for the dam projects in Kerala

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KEYWORDS
dam disaster
Mullaperiyar
dam stewardship

ABSTRACT

The issue of instability of the Mullaperiyar dam and associated controversies have aroused public and scholarly concerns over the stability of the other existing dams and many in the planning phases in Kerala. Dams were regarded as 'temples of modern India'. Proliferation of the dams dwindled development to a diminishing return level and then these temples were called 'tombs' of modern India. Now the instability factors of the dams too are the debates called 'dam dooms'. Older dams world over too have the inherent flows like the absence of any projections of their impact, structural strength or risk. But in developed countries later investigations and regulations brought them under strict surveillance and control. The processes of risk assessment, avoidance, control or mitigation for dams become an uphill task due to the conflicts in interests and stake holdings all along the life cycle of a project. Factors for the risks can be natural, physical or political. Political group include territorial, corporate, ethnic, cultural, socio-linguistic and fiscal politics. Issues like projects located outside the territory or jurisdiction of the owners, Owners or stakeholders living away from the risk zone but enjoying the fruits of the dam like regulated water or hydropower, conflict in interest between upstream and downstream entities, geopolitical stake holdings of cultures and groups etc impede on the safety surveillance and stewardship of the dams. A causal perusal into the geomorphic and geological framework of the project site will reveal that most of the current projects are located in a row in shear, fracture or lineament zones which defines the river valley systems. Most of the dams are located in the vicinity of the fault zone across the river system expressed as distinct water fall or cascade in the case of hydroelectric projects. These are all structurally and or seismologically vulnerable areas. Most of the river systems carry multiple run of river projects for hydroelectric power generation. All these indicate risks and hazards. 'Disasters occur when hazards meet vulnerability'. Land cover and land use in the upstream side of the dam is constantly changing by process of deforestation, large scale farming and terrain modification with indiscriminate soil erosion. Meteorological deviations due to processes from global warming to deforestation were beyond forecast while the existing dams were designed and executed. Among the globally documented modes of failure like Structural failure, Differential settlement, High uplift pressures, Settlement and cracking of concrete or embankment dams, Piping and seepage, Seepage and erosion along hydraulic structures such as outlet, Cracks in dam etc can be avoided by proper geological and environmental investigations. A comprehensive sociological and demographical mapping will help in assessing the risk and vulnerable situations. From the experience gained by the Impact assessment in several dams in Kerala the authors propose a protocol for the identification of the risks and vulnerability for the globally accepted factors and the stewardship practices to be followed in different life cycles of the dam projects.

Analysing the earthquake vulnerabilities for urban areas: In the context of Chittagong city

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KEYWORDS
unplanned urbanization
urban risk
urban vulnerability reduction
physical urban vulnerability
unplanned urban settlement

ABSTRACT

The historical seismicity along with recent seismic activities of Bangladesh indicates that our country is at high seismic risk. Earthquake has a great impact on urban areas rather than rural areas. The existing urban trend and urbanization process of Bangladesh, increases vulnerability to natural disasters like earthquake through the unplanned & high concentration of people and assets. The increasing urban risk results in vicious circle of disasters affecting urbanization and urbanization affecting disasters. The risk in urban centre is compounded due to unplanned urbanization, development in high risk zones. This paper interprets the urban vulnerability for earthquakes based on existing physical environment. Chittagong city, one of the major urban areas, experiencing physical vulnerabilities like, informal or unplanned settlements, poor infrastructures, existence of vulnerable built environments and so on. Rapid urban growth is causing deterioration and increasing the vulnerability of human lives, economy and infrastructures. If a strong earthquake attacking Chittagong city which may result damages and destruction of massive proportions and may create disastrous consequences for the entire country. This paper aims to analyze the issues related to physical urban vulnerability in detail to arrive at strategies or policy based solutions that are necessary to support the redevelopment of urban areas like Chittagong. By combining this vulnerability assessment of Chittagong city, this paper tries to give some strategic guidelines for the utmost use during disaster.

Disaster, risk and vulnerability due to earthquakes and designing of seismic resistant structure for mitigation

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KEYWORDS

hazard
urbanization
prevention
tectonic
vulnerability
awareness

ABSTRACT

The natural disasters due to earthquakes are not rare or unusual phenomenon in India. This paper examines the cause of earthquake, which accounts for more loss of life and property than any other natural phenomena. It analyses the hazard vulnerability in respect of earthquakes and discusses the usefulness of the Vulnerability Atlas, which is being developed by different organizations in India, for formulating proactive policies to face the threat due to natural hazards. It discusses the different aspects of natural disasters and gives a brief account of the statistics on disasters. Almost 85% of the country is vulnerable to disasters and 54% of the area lies in a high seismic zones and the number of people affected about 90%. This paper discusses the advances in designing seismic resistant structures and performance studies of progressive collapse of structures damage assessment to combat earthquakes and hazard vulnerability in India. It focuses on the fact that increasing urbanization and degradation of the natural environment on a global scale are having the effect in increasing the frequency and severity of disasters around the world. It discusses the statistics of disasters, prevention potential of disaster by societies and appropriate disaster prevention standards. It suggests for the designing seismic resistant buildings and structures for disaster mitigation and management, and it should be a part of sanctioning building plan to meet the challenges of sustainable development.

Hydrogeochemical evaluation of groundwater in Mamam river basin, South Kerala, India, using geospatial technology

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KEYWORDS

groundwater
Mamam river basin
laterite
over exploited block
quality zone map

ABSTRACT

Groundwater is an imperative source of water for domestic, agricultural and industrial purposes. It is a powerful solvent and dissolves minerals in rocks with which it draw closer contact. Agricultural and industrial developmental activities cause deterioration of groundwater quality. Ample provision of good quality water is essential for sustenance of life, hence regular monitoring of water quality is essential. In this work an attempt was made to assess the groundwater quality of Mamam River basin, located in the southern part of Thiruvananthapuram district of Kerala state. The study area lies in the Survey of India toposheet numbers D/14NE, D/14NW, D/14SE and D/14SW in 1:25,000 scale. One of the over exploited blocks of Kerala, the Chirayinkeezh block is positioned in the lower reaches of the river basin and hence the area was chosen for the study. The major rock types encountered are garnet biotite gneiss, khondalite and charnockite overlain by laterite. Water samples were collected from 76 open wells in both pre (May 2010) and post (August 2009) monsoon seasons. Physico chemical parameters like pH, EC, TDS, salinity, total hardness and other major ions were analyzed, by following standard methods. Acquired data was compared with the guideline values of BIS to review the water quality status in this region. The mean pH of post monsoon water sample is 5.33 and the range is between 4.1 and 6.9, while the mean pH of pre monsoon sample is 5.23 and it ranges from 4 to 6.9. It designates that in most of the places pH is far below than the permissible level. This observation identify that the water available in shallow aquifer is more of acidic character. In post monsoon season highly acidic pH values range between 4 and 5, was recorded from 19 locations, whereas in pre monsoon season it is enhanced to 28 locations. The mean value of EC and TDS in post monsoon season is 177.84 and 107.21 respectively and the analogous pre monsoon values are 197.31 and 122.9 correspondingly. Anomalous EC (2777 μs), TDS (1565 ppm) and salinity (1.75 ppt) values were obtained in a well near the coast at Thazhampalli during pre monsoon. This can be attributed due to the influx of salt water, created as a result of reduced recharging rate and over extraction of aquifer during summer period. Other worthy observation is Ca values of five pre monsoon samples exceed the highest desirable limits of BIS, while total hardness Mg, Na, K, Chloride, NO_3^-, SO_4^-, PO_4^{3-} and HCO_3^- for both seasons falls within the highest desirable limits. Acidic pH is found to be the main problem in the study area. It may be due to the percolation of water through laterite aquifer system, presence of coir retting yards and utilization of excess fertilizers in rubber plantation. Low pH can cause gastro intestinal disorders like hyper acidity, ulcers, stomach pain and burning sensation among the users and in addition to this pH value below 6.5 can cause corrosion in water carrying metallic pipes. GIS tool was used to prepare the groundwater quality zone maps, by assigning suitable rank and weightages to pertinent water quality parameters, which do have explicit control on the quality of water in the region. Arc GIS 9.3 software was used and it was done by overlapping of thematic maps representing distribution of pH, EC, TDS and Ca. In those areas where acidic pH was encountered needs momentous contemplation for recuperating the water quality by adopting fitting process to guarantee ample supply of fresh drinking water.

Benthic foraminifera from trenches in Kannur district, Kerala: Are they a pointer to the occurrence of a paleotsunami?

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Keywords

foraminiferal species
paleo-tsunami
chevron deposits
shoreline
Kerala coast

Abstract

Benthic foraminiferal assemblages provide considerable information about the environmental conditions they lived in, and are widely used in paleoenvironmental studies. In recent years, especially after the Indian Ocean tsunami on December 26, 2004, foraminifers and ostracods have been used to decipher the dynamics of tsunami deposits, their provenance and the water depth offshore from where they could have been scoured and deposited on land. This has helped in the characterization of tsunami deposits, which would be of immense utility in paleotsunami studies, provided a bathymetric and shelf foraminiferal database already exists. In search of ideal sites for paleotsunami deposits, several locations were selected in Kannur District, Kerala, based on the presence of peculiar, dark-colored sandy muds with several mollusks and gastropods. Trenches were dug at 13 sites, up to a maximum depth of 3.6 m. The sub-samples at 2.55 m below have yielded innumerable tests, both very well preserved as well as poorly preserved ones. So far, 14 benthic foraminiferal species have been identified; a lone specimen of *Globigerinoides* sp. (a planktonic foraminifer) was obtained but has not been considered for environmental interpretation as it most probably is a displaced specimen. The foraminiferal assemblage consists of *Ammonia beccarii*, *A. convexa*, *A. dentata*, *A. tepida*, *Asterorotalia inflata*, *Cribrononion simplex*, *C.* sp., *Elphidium discoidale*, *Helenina anderseni*, *Nonionoides boueanum*, *N. elongatum*, *Nonionella stella*, *Rotorboides granulosus* and *Pararotalia calcar*, of which *A. beccarii* is very abundant, followed by *N. elongatum* and *Helenina anderseni*. Available ^{14}C dates for the sub-samples at depths of 2.0 m, 2.8 m and 3.3 m are 4,685 $\pm$ 100, 4,845 $\pm$ 100, and 5,200 $\pm$ 110 years, respectively. These trench sites are about 5 to 8 km inland from the present-day shoreline and, based on the benthic foraminiferal assemblage obtained, there are indications that this region might have been an estuary, as modern estuarine benthic foraminiferal assemblages are strikingly similar. On the other hand, as the dates coincide with the Burckle Crater Impact in the Indian Ocean, the possibility of the occurrence of a paleotsunami $\sim$4,800 B.P. is also being explored. It is to be noted that deep-sea foraminifers and sediment have been identified from chevron deposits on the island of Madagascar, and their presence has been attributed to this mega-tsunami event, with the impact located at 30° 52′ 12″ S latitude and 61° 21′ 36″ E. Considering the distance between the Kerala coast and Madagascar, and also the fact that the extrapolated tsunami wave height could have been 250 to 300 m in the vicinity of Madagascar, the probability of a tsunami of 15 to 20 m height hitting the Kerala coast must have been very high. The results of this study are expected to confirm the provenance of the deposit and its relation to the extra-terrestrial impact-related tsunami event.

Remote sensing- and GIS-based seismic sub-zonation in north-western Tamilnadu

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Keywords

GIS
seismic zoning
Tamil Nadu

Abstract

There are 4 major seismic zones (zones II, III, IV and V) in India, based on the seismotectonic parameters, history of seismicity and certain geophysical parameters. Accordingly, most parts of northern and western Tamilnadu are categorized under zone III, while the other parts fall under zone II. Since such a broad classification system will lead to regional level instead of local information for efficient disaster management, there is a necessity to have sub-classes. This paper attempts to study the northern and western districts of Tamilnadu (Chennai, Thiruvallur, Kanchipuram, Cuddalore, Villupuram, Vellore, Dharmapuri, Salem, Erode, Tiruvannamalai and Coimbatore) and arrive at a map that indicates sub-classes of seismic zones in these districts. The factors considered for this study include: fractures/lineaments, history of earthquakes, and magnitude of earthquakes, Peak Ground Acceleration (PGA) and lithology. The input from remote sensing includes the use of satellite images to map the fractures, lineaments and lithology for the districts considered. The GIS based study involved both buffering and layer analysis. Buffering was used to demarcate the proximity of settlements to lineaments, while layer analysis involved assigning appropriate weights and ranks to the themes and preparation of the final zonation map. The result is a map indicating sub-classes/areas with high, moderate and low probabilities of seismicity within zones II and III of the north-western districts of Tamilnadu. Thus, it is seen that towns such as Arakkonam, Tirupattur, Katpadi and Ambur (belonging to the district of Vellore), which were hitherto categorized under Zone III, can now be categorized as: Arakkonam-*Zone III low*, Tirupattur-*Zone III low-medium*, Katpadi-*Zone III medium-high* and Ambur-*Zone III high*. Similarly, the other towns and villages can now be categorized into sub-classes. Thus, it is seen that such a remote sensing and GIS based analysis can help in prioritizing preventive measures to be taken for earthquake hazard mitigation and management in these districts.

Seismic risk analysis of lightweight concrete structures for dwelling

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KEYWORDS

lightweight concrete
normal concrete
seismic risk
earthquake vulnerability
pushover analysis
dwelling house

ABSTRACT

Many buildings, classified as dwelling houses, have been destroyed and the death toll considerable because of earthquake. The application of building codes and seismic resistant to dwelling is to ensure safety adjacent to earthquake by controlling risk. Furthermore, the development of lightweight concrete research had led to more reliable concrete with high strength concrete as well. The advantage related to earthquake is its weight which will reduce earthquake force for the structure using lightweight concrete. This paper discusses seismic risk of lightweight concrete compared to normal concrete in application to dwelling, especially in South East Sulawesi, Indonesia. The study conducted uses both combination of deterministic and statistical approach. It focuses on structural modeling of dwelling using lightweight concrete using SAP 2000 compared to normal concrete to establish structural behavior (deterministic part) due to earthquake force (statistical part). Failure mechanism will be performed by non-linear pushover analysis by taking uncertainty and variability of materials, dimensions and loads into account. Based on the result, seismic risk reduction factor for lightweight concrete is formulated and determined. In same location where they are modeled, it is found that dwelling with reinforced lightweight concrete performs better level of performance than reinforced normal concrete depended on the type of structure. Moreover, similar failure mechanism and ductility level are performed by both type of reinforced normal and lightweight concrete.

Landslides in coastal Uttara Kannada: Management towards risk reduction

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KEYWORDS

landslide
Uttara Kannada
GARP
SVM

ABSTRACT

The hilly coast of Uttara Kannada, interrupted with backwaters and river mouths, had no notable history of landslides until multiple slides struck Karwar during the rain-soaked early days of October 2009 causing live burial of 19 persons. That the proneness of the region to landslides has increased due to rising human impacts can be assumed considering the collapse of a hillside along Kumta coast during the peak rainy days of 2010 and in yet another incident near Karwar, boulders rolling down a steep hill hit a running train causing one death and injuries to others. A combination of factors may be blamed for the landslides that happened and likely to repeat, especially during days of excessive rains which are on the rise. Low lateritic coastal hills are formed of eroded and re-deposited materials from the Western Ghats through geological ages. Vegetation flourished on these hills until pressures from rising population and developmental activities erased bulk of it. The exposed soils of denuded hills got laterised through surface erosion, fine clay materials seeping down into the lower horizons leaving honey-combed iron rich, indurated surface laterite, a poor terrain for plant growth. The indurated surface laterite is an effective shield against landslides, except when deep vertical cuts are made exposing the soft clayey soil horizon beneath. The vulnerability of deposited lateritic hills to landslides increases if such deposits have taken place along the river courses or estuarine regions, causing capillary rise of water from beneath and descend of rain water through fissures and holes formed by rotten tree stumps. Rainy spells can soak up the soft soils in the interior triggering mudslides due to rupture of the hills, as is the case with the killer landslide at Kadwad in Karwar. Quarrying, pediment cutting, soil removal and stripping of vegetation increase risks. The granitic hills of Karwar coast are also posing potential landslide problems. The rocks here are of fractured type with ample pockets and cracks with trapped soils. Good forest cover could minimize risks. Deforestation in these is at its peak, caused erosion of top soil and water seepage into the interior of hills. Whereas the soils soak up and expand the granite rocks do not, unlike the laterite. Heavy rainfall acts as triggering cause for landslide hazards in such hills. Pediment cutting and quarrying add to the risk factor. Probable landslide prone areas in Uttara Kannada district and also in Kerala were predicted using algorithms GARP (Genetic Algorithm for Rule-set Prediction) and Support Vector Machine (SVM) in a free and open source software package — openModeller. Several environmental layers such as aspect, digital elevation data, flow accumulation, flow direction, slope, land cover, compound topographic index, and precipitation data were used in modelling. A comparison of the simulated outputs, validated by overlaying the actual landslide occurrence points showed 92% accuracy with GARP and 96% accuracy with SVM in predicting landslide prone areas considering precipitation in the wettest month whereas 91% and 94 accuracy were obtained from GARP and SVM considering precipitation in the wettest quarter of the year. To prevent landslide hazards, there should be accepted norms for each region, based on composition of soil and rocks, rainfall, quality and biomass of vegetation etc. Reduction of risk factor lies in providing appropriate vegetation cover, and any interference with the hills should be strictly adhering to norms of geology and ecology of the region.

Earthquake induced hydrological disasters

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KEYWORDS

seismosediments
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ABSTRACT

The pervasive effects of earthquakes are destructive. Earthquake is a disaster and it gives rise to some other hydrological disaster. During moderate to large magnitude earthquake in ravine area, a hillock of part of mountain gets dislodged and falls in river bed. It creates a temporary blockade or temporary dam and the flow of the river gets blocked. Usually such temporary dams are not stable and give way within few days. If there is a dam downstream, then the entire debris of the temporary blockade gets deposited in the dam. This is known as 'Seismosediments' and the process are known as 'Seismosedimentation'. A number of moderate to large earthquakes in the Himalayan area have been associated with such happenings. The deposition of Seismosediments in the reservoir reduces the effective and useful life of reservoir, which adversely affects the water distribution and power generation. During recent earthquakes in India and neighborhood such as Uttarkashi earthquake, the Kashmir earthquake Sumatran earthquake and Bhuj earthquake etc. the effect of seismosediments was extensively observed. The effect lasts for few years. In case there is no dam downstream, then the Seismosediments are deposited on the bed and banks of river. After the 15 August 1950 Assam earthquake of magnitude 8.6, the bed of river Brahmaputra had risen by about 2.5 to 3.5 m. This adversely affected the entire river regime. During the 19th January 1975 Lahaul-Spiti earthquake of magnitude 6.5, the river Para-Chu was blocked by a huge landslide and a temporary dam of about 35 m was formed. The blockade gave way within few days and the effect of this was seen at Bhakra reservoir, situated at distance of about 200 km from the epicenter. Huge amount of sediments were deposited in Bhakra dam. During the 8 October 2005 Kashmir earthquake of magnitude 8.0 a number of reservoirs such as Tarbela, Mangla etc in Pakistan were heavily silted by Seismosediments. Bapat (1988) (Bapat 1988 Earthquakes and River Regime, Proc. Int. Conf on River Regime, pp 423–429, John Wiley) has given a mathematical formula to calculate the amount of seismosediments. There have been a large number of similar cases from seismically active countries in China, Japan, Chile, Mexico, Indonesia etc. It is proposed to discuss some of the cases. The formula and the process of Seismosediments could be used for realistic projections of lives of existing and planned reservoirs. When a tsunami-genic earthquake occurs and it generates large tsunami waves, the mouth and deltaic areas of rivers are adversely affected. The river delta gets fragmented and affects the flow mechanism of river water near the mouth of river. It is proposed to discuss these points in the paper.

Disaster management education in India

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KEYWORDS

disaster education
CBSE
11th five year plan
disaster management curriculum
role of disaster education

ABSTRACT

The world is becoming increasingly vulnerable to Disasters which can strike at any time, and place. Natural Disasters have especially, in the last decade increased significantly in magnitude, frequency and impact, Some of the recent disasters that have affected the education sector in India are the Gujarat earthquake, 971 students and 31 teachers were killed, 1,884 schools collapsed; Tamil Nadu. Fire incident where 93 children died in a fire due to explosion of a cooking gas cylinder; Kashmir earthquake (2005) where 17,000 students died at school, and 10,000 school buildings destroyed, no one can forget the school in Leha washed out in cloud bursting with many children recently. The event that unfolded in the Kumbakonam fire tragedy which took the lives of 93 children reiterate the need to have school level emergency preparedness and response plans, National policy on Disaster Management has also stressed the issue of educating professionals in this field. Government of India in its Tenth and Eleventh Five Year Plan document, have emphasized the need to enhance knowledge, skill and values to reduce the impact of disasters. The Tenth Five Year Plan emphasized the need for integrating disaster management in the existing education system. In addition, the government of India launched many disaster risk mitigation initiatives, amongst the inclusion of disaster management in school and professional education are important. The Central Board of Secondary Education (CBSE), has initiated Disaster Management in the school curriculum, with emphasis on first aid, search and rescue skills, disaster resilient construction practices etc. At the undergraduate level and above, some universities and Institutions are offering courses on Disaster Management. These includes the universities of Mahatma Gandhi University, Kottayam, Roorkee, Chennai, Pune, RTM Nagpur, IITs, Yaswantrao Chavhan Academy of Development Administration, National Institute of Disaster Management, National Civil Defense College, Tata Institute of Social Sciences, and Indira Gandhi National Open University. There are some other initiatives taken by Government of India to develop a model curriculum and organized seminar, workshops and conferences to educate the different strata of the society. NGO's are also imparting education through trainings. The investments in disaster education, public awareness, community leadership development, disaster education of unemployed youth, physically challenged, elderly, women and school children are essential. A large number of professionals require training and retraining for which we will have to generate quality teachers, text books, training kits, etc. This will call for innovation in disaster education, Disaster Management Education in India is still in its infant stage it is needed to take out from the classroom to the open community and from formal education to the informal education to the entire community because, Disasters brings along with them heavy loss to life, property and livelihood. So it is time to make disaster management a way of life.

A disaster management plan for Moonnilavu Grama panchayath with special reference to landslides

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KEYWORDS

landslides
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susceptibility analysis
mitigation measures

ABSTRACT

The frequency of disasters due to landslides in hilly areas, foothills of midland and highland are increasing year after year. The western flanks of Western Ghats covering the eastern part of Kerala is identified as one of the major landslide prone areas in the country. This study attempt to prepare a disaster management plan for a grama panchayath with special reference to landslides, with the help of landslide hazard zonation of the area. The frequency ratio method were used for the hazard zonation and landslide susceptibility analysis. From the study it is found that around 48.37% of the study area is in critical and unstable landslide susceptibility zones and the slope and soil thickness are the most important parameters influencing landslides and the heavy rain during the monsoon season is the main triggering mechanism. Also landuse practices such as contour bunding, terracing and slope cutting increasing the landslide vulnerability. Unlike other natural disasters were restoration may be feasible, landslides usually create permanent unstable sites that often suitable only for designation as undevelopable open space. In this paper we consider mechanisms to reduce the impact of landslides as will as an effective landslide management strategy suggested.

Environmental risk assessment and vulnerability analysis of tourism in a high altitude destination in Kerala, South India

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KEYWORDS

Western Ghats
sustainable tourism
endemic species
species vulnerability

ABSTRACT

Vulnerability is a function of the prevalent hazards and the characteristics and the quantity of resources at risk to their effects. Vulnerability assessment results in an understanding of the level of exposure of people and property to the various natural hazards identified, including physical assets, the loss of potential crops, trees, livestock and fisheries. Klein and Nicholls (1999) have suggested that vulnerability is multi-dimensional, with biogeophysical, economic, institutional, and socio-cultural elements. The vulnerability of a system to climate change is a function of its exposure to negative effects and its ability to cope with those effects (McCarthy *et al.*, 2001). Tourism is an important industry in Kerala for economic growth, tax revenues, and foreign exchange earnings. Vagamon located in the border area of Idukki–Kottayam districts of Kerala is a rising tourism destination in the High range regions, scattered at a height of about 1,100 metres above the mean sea level with delightfully attractive meadows, open forests, waterfalls and valleys. This area is unique for its grasslands with laterite soil type. The marshes and *sholas* are being drained, cleared and filled at an alarming pace. The marshes that act as 'sponge' by absorbing and storing water are fast vanishing. Introduction of tourism development activities should not result in deterioration of the ecology of the hills. Extensive developmental activities like road construction in hilly areas will undermine the stability of hill slopes and may cause hazards like landslides. Hence the concept of sustainable development is very relevant for hill areas. The study presents an assessment of the vulnerability of the tourism sector in Vagamon and its impacts to the natural ecology. Vagamon is a hilly grassland area coming as part of Western Ghats; the biodiversity rich endemic area. The total land use of the study area is calculated as 104.3 sq. km. Majority of the land area consists of open scrub with the land area 76.4814 sq. km in 1967, which is reduced to 71.4873 sq. km. in 2009. The quadrate analysis for the quantification of trees, herbs, shrubs and seedlings and the grasses respectively. There were 8 species of trees were identified with *Memecylon* and *Cinnamomum* with great frequency of occurrence and *Syzygium cumini* with lesser frequency of occurrence. The high relative basal area is observed *Syzygium cumini* and it also shows high important value index (IVI). The Vagamon grasslands, coming under part of western ghats area consists of 44 sps. of RET species with special ecological importance, of which 22 sps. were rare, 9 sps. were threatened, 6 species were vulnerable, 2 sps. were endangered and 5 sps. were possibly extinct categories. There are 59 species of birds observed in the study area by extensive field works in the area under investigation and the identification of birds is based on identification key and standard field guides. 28 sps. Of southern Indian birds are classified by Birdlife international are globally threatened with extinction (Birdlife International 2001, 2003). The grasslands are considered as one of the most important bird habitat in southern India. A total of 112 species of butterflies belonging to five families were recorded during the study period. The family Nymphalidae dominated with 44 species followed by Lycaenidae (24), Hesperiidae (19), Papilionidae (13) and Pieridae (12). This included four species endemic to the Western Ghats. Since the late 1980s, sustainable development has become indispensable in development studies in general and in tourism research in particular. The sustainable tourism is essentially an issue of managing visitor numbers, activities and behaviour and to prevent an unacceptable level of environmental degradation, resulting in a subsequent loss to the economy and culture of the area. The concept of carrying capacity is the long-established mechanism by which sustainability may be gauged (Hunter and Green, 1995; Lindberg *et al.*, 1997; Wright, 1998).

A study on the stability of slopes under seismic conditions

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KEYWORDS

slope stability
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ABSTRACT

Considerable attention is being paid in seismic slope stability and permanent displacements of natural and man made embankment slopes. The failure of earth dam or natural slope during earthquakes can lead to significant losses. Also major damage without failure can have serious economic consequences. Hence, the seismic performance of these structures requires appropriate evaluation during their design. Such performance is best evaluated through an assessment of the potential for seismically induced permanent displacements. These displacements depend to the large extent on geotechnical properties of slope material and strong ground motion parameters during an earthquake. This paper presents numerical studies on response of slopes due to dynamic loading based on finite element analysis. Model embankments of both cohesionless and cohesive soils have been considered. The parameters selected for the dynamic analysis include slope heights of 5 m (low embankment) and 18 m (high embankment) and slope angles of 30°, 35° and 40°. The effect of earthquake ground motions of different amplitudes and frequencies in the range of 0.1 g to 0.4 g and 1 Hz to 4 Hz respectively have been studied. The model slopes are analyzed for their stability under static conditions as well dynamic conditions. The results are presented in the form of factor of safety against slope failure under static and seismic conditions and settlement of crest of slopes. Based on the analysis, it is found that increasing displacements occur in slopes with increasing amplitudes of vibrations. However, maximum displacements have been observed in slopes of high embankments (18 m) at a frequency of 2 Hz when compared to low height embankments. Further, increased amplification of accelerations at the crest of the embankments have been observed in the case of both low and high embankments.

Interface between research and action: A case study of Tamilnadu in the context of Indian Ocean Tsunami

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KEYWORDS

gender issues
women needs
practice and research in disaster management
gender analysis
social inclusion

ABSTRACT

This paper is an endeavour to focus on how research unearths the implications of gender inequalities and discriminations during and after disasters. Research in this sense becomes a powerful tool of advocacy for changes at the policy and programmatic levels. Programmes which remain rooted in gender research do pave the way for far reaching changes in gender roles and relations at all phases of disaster response. Catastrophic natural hazards like tsunami provide unique opportunities to look at the consequences of the pre-disaster gender vulnerabilities For example, disaster like tsunami occurs in nature but its impacts are shaped by the social world in which it occurs. For example, Women died more than men, women became poorer relative to men, women's loss were not assessed and documented, women's specific needs, including reproductive health needs, did not attract the attention in the initial phases, there were adverse consequences of male dominated relief distribution and needs assessments. The entire gamut of gender based disadvantages and its long term consequences on women and gender relations needed wider research so that intervention at all phases of recovery could be well directed towards mainstreaming women's gender interests in the recovery process. The present paper which elucidates the gendered issues of tsunami is based on a field based study which was supported by Oxfam and carried out by a team of independent researchers. The purpose was to generate a body of knowledge by articulating issues through participatory research process. This was done to have effective interface between research and practice; to bring in corrective steps to engender policies which would further the gender equity in both disaster recovery and development processes. Apart from articulating issues, the research also focuses on the best practices of the NGOs in the direction of gender mainstreaming: the concrete outcome of research guiding the practice. This paper brings in several case stories, from a gender lens, of major gender issues which were unpacked through field based studies and the best practices which challenged the entrenched existing institutional norms at the community, market and state and family levels. The issues range from higher mortality rate of women relative to men and its far reaching effect on the status of girls, absence of women specific clothing and sanitary needs to that of their home based occupations in the loss assessments and recovery processes. The issues also bring forth how the aid remains skewed in favour of men for the simple reason of women's pre-disaster weaker social, political and economic status relative to men, thus reinforcing the existing gender inequalities. As well as underscoring the interface between practice and research through field based examples, the paper shows how gender as an analytical tool could be used to analyse the complex-yet-largely-ignored-phenomenon of gender relations that shape political, economic and social realities affecting women and men differentially.

Geotechnical assessment of disastrous landslides occurred in mid of September 2010 at different places of district Bageshwar, Uttarakhand

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KEYWORDS

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ABSTRACT

Numerous landslides, land erosion and subsidence occurred at different places of district Bageswar, Uttarakhand in the month of September 2010 initiated by heavy rainfalls and cloud burst disaster caused 19 human deaths, widespread damage to human settlements, cultivated lands, irrigation canal, bridge, village foot tracks and major communication routes. More than 50 major landslides classified as rock slide/fall, debris slide, rock-cum-debris slide, and slope wash debris flow and bank erosion of different *nalas*/streams have been recorded. The slides have resulted in huge debris flow that flooded and deposited over human settlement, communication routes and cultivated lands. The studied data that steep slopes, high relief, thick slope wash material/overburden, complex fold, numerous faults and proximity to thrusts rendered the slopes highly vulnerable to mass movements. Further, anthropogenic activities and varied geological, hydrogeological, slope erosion and structural conditions have created adverse conditions for numerous debris slides/falls. The paper as a special reference has discussed a major landslide named as '*Killer landslide*', which occurred on 18 September 2010 and hit a private primary school, Saraswati Shishu Mandir, at Sumgarh village, *Tehsil* Kapkot where in 18 children of Classes I and II died (buried alive under tonnes of rock debris) and over 25 children got severely wounded. Generalised suggestions and recommendations have also been discussed for mitigation of this problem so that the recurrence of damage caused by similar incidences in future can be minimised.

School and community horticulture enterprise — A livelihood option to ensure food security, sustainability and improve child nutrition

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KEYWORDS

food security
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ABSTRACT

A large part of the rural economy in India is dependent on agriculture. At present, the livelihood of many farmers owning marginal and small land holdings is at threat because of the low productivity of the land and depleting natural resources due to frequent **droughts**, making subsistence farming non-remunerative. Farmers in Karnataka have limited access to credit and opportunities to address the social and economic needs of small farmers have been few and far between. However, the emergence of Self Help Groups (SHG) has enabled rural women to have access to micro-financing. This has created several opportunities for women-led initiatives in rural areas. In light of such circumstances, the School and Community Horticulture Enterprise (SCHE) in support with Sir Dorabji Tata Trust (SDTT), initiated by Technology Informatics Design Endeavour, a Bangalore based NGO, is aimed at using greenhouse horticulture as a viable livelihood option for small and marginal women farmers, who are within the economically weaker section and belong to a socially backward community in the Tiptur Taluk of Tumkur district. The area is a semi-arid region and water levels have gone down in the recent past due to climate change induced droughts which lead to water scarcity and large scale exploitation of groundwater. The objective of the project is to ensure **food security** through **sustainable agriculture** and to improve child health by contributing to the national mid-day meal scheme for school children, thereby increasing the **nutritional** food intake of school children. Thus, the project created a viable income generation opportunity for women with access to small land holdings, which they use to grow high value and low volume/low value and high yield crops, earning about Rs 30,000–40,000 per year in a greenhouse structure of 200 sq. m. area. The roof of the greenhouse has been used to collect rainwater, which in turn is used to irrigate the crops in the greenhouse through a drip irrigation system. The SCHE project motivated the women to donate about 10% of their produce towards the mid-day meal scheme (which was initiated by the Government in 1995, to improve enrollment and child health and was not been significantly successful due to poor nutritional quality of the meal). This improved nutritional quality by providing additional 50gm of vegetables/child/day and papaya fruit grown in open field. This act of charity empowers the women by earning them respect and support from the community. This has already been implemented in ten schools in Tiptur Taluk of Tumkur district, Karnataka State. The enterprise supported about 380 lower primary school children, which also led to an increase in attendance as well as an improvement in the health of children. The project is conserving about 13,50,000 litres/year and saving about 1230 kWh of energy/year, which is equivalent to 904 kg of CO_2, and results in a significant reduction of carbon footprints. Simultaneously being energy saving and water securing oriented, the project has created an environment friendly, economically viable and socially acceptable livelihood alternative, leading to sustainable agricultural development and food security. In addition, the projects multi-faceted benefits also include the provision of viable options to marginalised farmers, addressing women's empowerment and improve children's health in rural areas, thereby having the potential to bring about social, cultural and economic transformation.

Safer schools, safer hospitals and safer people — a people-centered disaster management approach

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KEYWORDS

over-population
DM act
safe hospitals

ABSTRACT

We live in a World which is buffeted by natural and man made disaster. No country or individual, rich or poor, is immune from disasters. People in India are highly vulnerable to disasters due to unsafe buildings, over population, poverty and lack of awareness and education regarding enhancing threats of disasters. There is a growing evidence to suggest that disaster occurrences have undermined safety of schools and health facilities most. It is important to understand that schools and hospitals are interface between the community, the people in governance, and private sector, and perform different functions. Schools and Hospitals are much more than brick and mortar. They are home to build knowledge of the youth in safe environment and to provide critical health services when these are needed most in disasters. These are the settings in witch school children educate, grow and build themselves towards the path of progress and prosperity, also, health workers work tirelessly to ensure their dedicated services to patients impacted by disasters in hospitals. Schools and hospitals also have a symbolic social, economical and political value and contribute to a community's sense of security and well being as such, they must be protected from avoidable consequences of disasters, emergencies and crises. In assessing India's proneness to natural and man-made disasters and vulnerability of its schools, hospitals and people, it is noted with concern that India and disasters are some how conterminous over centuries, yet, least prepared. To deal with such a scenario of continuous threats and consequences, in past 5 years or so there has been a purposeful swing in the process of disaster management nationally. The disaster management act of year 2005 (DM Act 2005) lays down mechanism for effective emergency response at the national state and district levels. Also, there has been rich contribution by UNISDR, experts, academia and technocrats to guide people in governance and prepare needed human resource to put the process of disaster risk reduction in its needed priority. It may be a good beginning, yet too little and too slow for millions of people at grass root level. This study of Saritsa Foundation, s campaign argues that mainstreaming people in the process of resiliency involves weaving them together which will transform Hyogo frame work of Action in to a reality to have safer schools and safer hospitals and safer people. The campaign study analyses importance of people centered and decentralized approach which is a paradigm shift from 'Top to Bottom' methodology of resiliency to disasters which has been conventionally practiced, to 'Bottom up Ward' approach. It entails a new set of innovative and analytical ways to develop safety culture amongst people by building their capacity. It also strengthens the principle approach adopted at Global Platform for Disaster Risk Reduction (UNISDR) 2009 which priorities that 'Critical services and infrastructure such as health facilities and Schools must be safe from disasters by 2015'.

Flood disaster preparedness & response: Experiences from the Padma riverbank areas of Bangladesh

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KEYWORDS

flooding
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disaster preparedness

ABSTRACT

This paper outlines a part of a research and design project based on work undertaken for the B.Arch. at the Department of Architecture, Bangladesh University of Engineering & Technology in 2007–08. This study starts with the intention to ease the life style & settlement pattern of the rural dwellers of the river bank areas respond to hazards like floods. Floods in the deltaic valley of Bangladesh is not merely an environmental issue, they play with the very fate of the nation, not to speak havoc they wreak on the economy of these bank side areas. The findings of the study can be integrated into establishing official flood management measures to effectively manage flood disasters in flood prone areas which would greatly reduce flood losses. Bangladesh is one of the most vulnerable countries to climate change due to its geographical location and geomorphologic conditions. Popularly known Bengal Delta formed by three river systems which is repeatedly affected by climate change through recurrent natural hazards. As floods are climatologically phenomena thus persistence of higher rainfall can lead to greater intensity of regional and local flooding. Floods in Bangladesh are a complex phenomenon. They pose enormous threats to the population through loss of life and economic damage, but at the same time, moderate floods contribute to the fertility of the land. Flood hazards of bank side areas of rivers are difficult to control through structural measures; Flood proofing through assistance to self help measures to reduce the damage to property and stress are largely accepted preventive efforts that these people have practiced. Adaptations towards the impact of climate change could make them quite self-dependent in facing disasters. This paper focuses on formulating future action plans and some immediate incentives to improve the physical environment that are better suited to the people of river bank areas with frequently changing context. To develop a self-sustain community and an adaptive building-for-safety in response to observed or expected changes in climatic stimuli beside the riverbank areas, study goes through the geo-morphological & hydrological analysis and vulnerability assessments of built form in this area. Finally goal is to provide zoning guidelines through flood level predictions & suitable shelter options which would help the peasants at the time of emergency.

Orissa tornadoes: Select discussions

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KEYWORDS

Tornado
Brownian motion
Orissa

ABSTRACT

In the year 2005 May, a tornado was recorded in the western fringe of Bhubaneswar city (20.15°N/85.52°E), Orissa, known as Ghatikiya. No loss of life or property was reported. Farm land was marginally affected. Figure 1 is the scanned image of the said member when it had full scope form. On that date in the following hours a severe storm had hit the city centre, which is to the SE of the location of the event. We can see the background is bereft of cumulus clouds, while the stem of the tornado is connected to a patch of black cloud. The base is churning up large volume of dust/sand and is rain less. The top mid portion is visually less opaque i.e., it is less dynamic region in the whole system, which is why, the structure bends therein. The event is progressing over near flat land which is covered with deciduous shrubs. Bhubaneswar is core cyclone region. Tornado presents quite a contrasting picture and mechanical structure from that of the cyclone. Both the Tornado events were of <15 minutes duration each. In Figure 3 we see a tractor has turned turtle. Both are iron make machines and weigh $>\frac{1}{2}$ MT/each. In spite of a narrow cross section, a Tornado (within the stem) inflicts a 'lift' to any object irrespective of its weight. Such 'lift' phenomena was not encountered even during the event of the Super Cyclone of October 1999. In this instance too rooms, hutments and even concrete structures with ajar door and windows suffered, while that and those which all were firmly shut from within (by inmates), and were not affected. However, vehicles turning turtle remains to be explained. We examine published literature, interview a wide range of experts and field examine the events. Our finding is that (i) vehicles/firm implements (excluding *sagadas*-bullock carts), fishes, bovines and other ruminants were lifted and thrown asunder (ii) whereas, that and those which did not have inflated tyres or large air-way systems were not effected (iii) human casualty indicated extensive pulmonary rapture, cerebral hemorrhage and asphyxiation. We know the stem develops a 'atmospheric low' of the order 800–600 hPa. Tyres have a positive pressure $\sim$32 psgi. 1 psgi = 6.894757 (say 7) hPa. So the gross contrast between the inflated tyres interior coupled with that of the transient low created by the Tornadoes stem works out to $(32 \times 7) = 224$ hpa + 200 (1000–800) = 424 psgi less than that of the mean sea level pressure. This makes the trapped air within the tyres act as compressed air bubble(s) locked in fluid bed. Compressed air tries to come out at a force of 424 psgi. This imparts very high buoyancy to the inflated wheels and inflicts a rotary motion to gain the preferred place of position (in relation to the aberrated atmospheric column pressure). Bulk mass modulus shifts and centre of gravity alters in a reverse manner along the vertical. The item then becomes air borne. In the case of the jeep the hind becomes relatively more buoyant. In the case of the tractor the large wheels play the decisive role. A combined play of the principles of Pneumatics, Fluid Mechanics and Brownian motion manifests in nature. Tornadoes in coastal Orissa is a meteorological member of the Spring equinox period.

Creating public awareness about earthquake and precursors

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KEYWORDS

earthquake precursors
prediction and warning
biological sensors
community awareness

ABSTRACT

Experience from previous destructive earthquakes in India indicates that the Government Administration comes in picture with the masses only during post-seismic periods. This is mostly for rescue, evacuation and providing food, cloths, tents, blankets, medicine etc. This was seen during Latur (1993), Bhuj (2001), Andaman (2004) and Kashmir (2005) earthquakes etc. Such post-seismic measures do not help in alerting the people and mitigating the seismic disaster. If common people are educated and informed about some reliable seismic precursors, it would help in saving lives of several people. There are some reliable seismic precursors which every person could see. If people are educated they would prepare to face the seismic contingency. A pamphlet for this has been prepared and it is intended to be released in seismically active states in India. The precursory parameters are divided on time axis and not by the nature of the parameters. The Seismo-electromagnetic precursor on reception of radio waves is seen about 60 to 100 hours before earthquake. The same effect for television in the form of audio, visual and spectral disturbances is seen about 10 to 12 hours before the earthquake and the same is found in the form of malfunctioning or non-functioning for mobile telephone about 100 to 150 minutes before the earthquake. Abnormal animal behavior is observed about 10 to 12 hours before earthquake. Similarly, human medical precursors are seen about 15 to 20 hours before earthquake. When such precursors are seen at a particular place people should telephone nearby location within about 20 to 30 km radius and verify whether such precursors are also seen at several places in the radius of about 20 to 30 km then it would reasonable to expect the occurrence of a medium to large magnitude earthquake. Appearance of unusual 'earthquake clouds' occurs about 10 to 30 minutes before the earthquake. These clouds are of unusual size, shape and colour. Such informative pamphlet would be translated in the regional language and would be distributed to large number of people.

Nanotechnology — A new frontier for food security in socio economic development

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KEYWORDS

sustainable agricultural
nanotechnology
in food sector
food security
in ecology
in bio-magnification
in social life

ABSTRACT

Agricultural sustainability is facing challenges both in respect to food security and ecological vulnerability all over the world. Day by day the recorded food prices have been noted while the food production seems to be drastically low. This brings out the issues of sustainability covering both agro-ecological and socio-economic indicators. It has been observed that the number of hungry people will be more than one billion within 2015. Naturally, so many technologies are being adopted in the agricultural field to boost up the food production. In this context one of the most recent and unique technology — Nanotechnology, has been adopted in the field of agriculture. The applications of nanotechnology in the food sector are newly adopted and its future is highly predictable. This technology has been adopted by several companies for exploring the potential of nanotechnology for use in food or food packaging. As we know that the nano means 'dwarf'. Nano particles are engineered materials. Its structures and systems that operate at a scale of 100 nanometers (nm) or less (one nanometer is one billionth of a meter). This nanotechnology can break through in food sector by producing nano food, nano food packing, nano farming, etc. Still several leading scientists would like to predict that this technology may create some risk in ecological, health and in socio-economic sector. In the present decade it has been observed that the use of the nanotechnology can create some toxic effect in food chain, in bio-magnification and also in food web. Naturally, it should be look out the toxicological effect of this great technology. Thus the article has been dealt with the prospect of this nanotechnology in food sector as it is related with the socio economic development. Several reports helps to propose, the use of this technology can penetrated in the food chain and also can alter the normal processes of energy flow. In this point we have to think the use of nanoparticles in a proper way otherwise natural disaster will appear in the society in future.

Creating an empirically derived community resilience index for disaster prone area: A case study from Orissa, India

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KEYWORDS

disaster resilience
disaster index

ABSTRACT

'Resilience can be understood as Capacity to absorb stress or destructive forces through resistance or adaptation l capacity to manage, or maintain certain basic functions and structures, during disastrous events l capacity to recover or 'bounce back' after an event . 'Resilience' is generally seen as a broader concept than 'capacity' because it goes beyond the specific behavior, strategies and measures for risk reduction and management that are normally understood as capacities. However, it is difficult to separate the concepts clearly. In everyday usage, 'capacity' and 'coping capacity' often mean the same as 'resilience". The State of Orissa is located in the eastern coast of India at 17° 49′ N to 22° 34′ N Latitude & 81° 29′ E to 87° 29′ E Longitude. The state is divided into five morphological units: Mountainous and Highlands Region, Coastal Plains, Western Rolling Uplands, Central Plateaus and Flood Plains. It has been found out that the state is hub of disasters. The state was recurrently victimized by climatic chaos (floods, droughts, flash flood, cyclone, heat wave, high risk zone for earth quake & lightning) causing people more vulnerable and pushing state development more backward. Magnitude of poverty, hunger, trafficking, distress migration followed by social exclusion has widened the development gap many fold, despite the presence of rich resource base. At this context, there is an increasing need to determine which community characteristics are most resilient to disasters. This research paper proposes method to quantify community resilience. The factor analysis method results in a weighted additive index model of 10 variables to derive district wise community resilience. These variables are from five capital groups namely Social Capital, Economic Capital, Human Capital, Physical Capital and Natural Capital. From each capital two variable are taken for index these are Rural School, Health Center, Par capital income, % of Below Poverty Line Families, Educational attainment of the population, which can be (measured by the number of years of formal schooling of the average person), Migration, People having concrete House, Road density, Forest cover and Access to safe drinking water.

This study represents a preliminary attempt in quantifying community resilience. It outlines the method that can be used to define resilience index and offers a general guideline about the variables that might contribute to a communities ability to recover from a disaster. The 30 districts of Orissa is ranked according the score and categories the districts in five groups i.e. least, low, moderately, high and highly resilience.

Building climate resilient cities: Learning from abroad and present response mechanisms in Indian cities

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KEYWORDS

climate-resilient cities
NAPCCC
DRR

ABSTRACT

Climate Change as it relates to cities is an important issue for discussion today considering the likely impacts of climate change that we have already started experiencing and would experience in the coming future. Half the globe is urban today and three quarter of carbon dioxide in the world, which is the biggest greenhouse gas is emitted by urban areas (Darryl D Monte, 2007). Cities are known to be highly energy and resource intensive entities, besides being the economic hubs of the country. Cities account for 1/6th of the freshwater the world guzzles, a quarter of the wood harvested and two fifths of the material and energy flows. According to the IPCC (2007), cities are responsible for 26% of direct greenhouse gas emissions. Also, the global rise in temperature, more frequent extreme events, rise in sea level and glacier melting, all impacts of climate change, put the cities to threat subsequently putting to threat the very economic basis of many a developing countries. It is therefore essential to have concern about the issue of climate change (one of the important and irreversible by product of environmental imbalance) specifically in terms of how it relates to cities and urban areas. Current government policies and urban development patterns encourage sprawling and auto dependent development, which in turn becomes the root cause for GHGs emissions, and subsequent global warming and climate change (Reid Ewing *et al.*, 2007). Climate change is a global issue but its impact and its cause are rooted somewhere at regional and even local level (Changnon, 1992). Responses range from adaptation, mitigation and Disaster Risk reduction and preparedness. While disaster preparedness — risk reduction and mitigation has gained attention all over the world, similar attention to adaptation strategies is yet a distant dream. More over the discussions within the scientific community increasingly suggest an integrated approach towards responses to climate change to reduce risks and vulnerability to urban population, particularly the vulnerable urban poor and slum dwellers and to build resilient cities. Many Governments in the west have taken initiatives and offer a lot of learning from their own experiences and strategies that they have adopted as a response to current climate variability and future climate change. Some of the typical example would be the Plan NYC-2030 (New York City); The City of London Climate Change Action Plan, Climate Change Adaptation Strategy-2006 for the city Durban. In India, the launch of the National Action Plan on Climate Change (NAPCCC) with its 8 Missions that target various important sectoral interventions has brought about a significant change in the way India views climate change and sets the ball rolling to combat climate change impact in a holistic way. This paper however, focuses on how Indian cities are prepared to respond to the new threat of climate change and variability. Citing example such as the Components of National Mission on Sustainable Habitat, The Delhi Climate Change Agenda, Initiatives at city levels like that of city of Surat in Gujarat and non-government externally funded initiatives like that of Asian Cities Climate Change Resilience Network (ACCCRN), the paper captures insights on the challenges and opportunities that emerge from these initiatives. The paper also captures the western examples and draws synergies for Indian cities from these initiatives. The paper significantly contributes to the conference by differentiating in the way the problem is approached in the many examples cited and draws learning for Indian Context to help build resilient cities and before that help build integrated holistic mechanisms to adapt, mitigate and reduce disaster risk and vulnerability of cities in India.

Community health risk assessment on mercury contaminated fish consumption at Cochin backwaters

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KEYWORDS

estuary
mercury
fish
health risk assessment

ABSTRACT

Concern over potential human health risk of mercury associated with fish consumption has led many nations to issue consumption advisories and limits. Dietary survey over populations can provide essential information for exposure assessment, risk characterization and risk management. The current study focuses on human health risk assessment associated with the mercury contaminated fish consumption by human population living at the banks of Cochin backwaters. Fish samples were collected and analyzed for mercury content following standard methods. A random survey was conducted to evaluate the fish consumption rate and health status among the people. A total of 227 peoples of 44 years (average age) and average weight of 56 kilograms were surveyed. The mean methyl mercury (MHg) concentration in the edible parts of fishes was 0.67 mg/kg (wet weight) and the mean total mercury (THg) concentration was 1.03 mg/kg. The estimated fish consumption rate was 34 mg/day which is slightly higher than the national average of 30 mg/day. The hazard index calculated for the mean concentration of total mercury as per the present study was 2.09, which indicates a high risk to human beings. The intake of methyl mercury calculated in the study was 2.85 microgram MHg/kg body weight/week which is much higher than the reference value suggested by FAO/WHO-JECFA, US, Canada and Japan. The health survey conducted on symptoms of mercury poisoning has indicated no adverse effect so far on the sample population of this region.

Urban intervention for an eco-city based on its water bodies: case study — Dhaka, Bangladesh

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KEYWORDS

water bodies
urban intervention
urbanization
transformation of water bodies
eco-city

ABSTRACT

Bangladesh the largest delta in the world is a land of Hydraulic civilization. The capital city Dhaka was built based on its water culture. Water culture has paid powerful role shaping the histories, societies and economics. Bangladesh is worlds largest delta system and has the greatest flow of river water to the sea of any country on earth. Water Urbanism is one hand is the Science of a city and on the other hand it is the discipline that holds the capacity to steer the transformation of the city and to design rational development. Dhaka the capital of Bangladesh is the seven largest populated city of the world which was initially established based on its water bodies in the 14th Century. The establishment is evident from the 7th century. The city is bounded by three rivers all around. This was a city of more than fifty canals and many ponds even in the 1950s. As the largest delta of the globe it is common to have many water bodies in this low country. The huge rate of urbanization and the so-called modern city actually concurred water based city and the dialogue between waster and city was collapsed. Water appears to be one such issue that is (re)conquering the contemporary agenda of urbanism. Now it is not surprise as we are constantly reminded of the consequences of global warming and rising of sea levels, uneven distribution of resources. Water bodies suppose to be the life of the city which should work as the line of communication, natural drainage and ecological space. These water bodies and surrounding area should be the major open spaces and space for recreational facilities of the city. Over the last few decades the cityscape of Dhaka, the capital city of Bangladesh, has been experiencing a transformation in terms of its water system due to rapid and uncontrolled urbanization. The paper will focus on understanding of water culture of the deltaic city of Dhaka and analysis the metamorphosis of water bodies of Dhaka city. Over the last century the city's water bodies had transformed enormously due to urbanization especially in last 20 years. The paper will look for the city water bodies evolution with growth of the city and impact on urban life. In the second phase of the paper after synthesis searching for possible reclamation of water bodies will be taken in to account. The paper shall look for an urban design solution for an eco-city based on its water.

21st century tech — Transforming community engagement in disaster preparedness, risk reduction and response

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KEYWORDS

SMS
GPS
crowd sourcing

ABSTRACT

Community engagement is increasingly recognised as a pre-requisite of good disaster preparedness, response and recovery, yet remains a major challenge for humanitarian agencies and governments alike. Some perceive the advantages offered by new technologies such as GPS handsets and smart phones in communicating with communities, and are beginning to invest large amounts in developing or purchasing commercial systems and equipment. Yet this ignores the increasingly wide reach of the mobile phone, accessible to millions through village phones, family members, and local enterprise. Mobile coverage is increasing year on year. Furthermore, SMS is increasingly the go-to technology for populations seeing an opportunity to save time and money — witness the huge success of mobile banking in Kenya and Pakistan, and the level of trust in the technology which that implies. FrontlineSMS is free, open-source software available to not-for-profit organisations all over the world, which allows them to turn a computer and a mobile phone or GSM modem into a communications hub cable of interacting in sophisticated, responsive ways with hundreds of individuals. The software is designed to be picked up by any user swiftly, and interacts with users on the ground using normal text messages — no other costs, equipment or training are needed. FrontlineSMS has been used for early warning systems, security alerts, SMS helplines, and data collection, among hundreds of other uses in disaster response and risk reduction contexts since downloads began in 2007. This paper explores user case studies, including those utilising complementary technology such as Ushahidi, in depth and explains how agencies responding to emergencies can use SMS to communicate with the people they are working with. More recently, however, FrontlineSMS' sister projects in health, mobile money, and legal services have built sophisticated data management tools on top of the core platform which allow organisations to run complex databases without ever needing an internet connection. The case study concludes by setting out how such databases could allow administration of aid distribution, including cash transfers, saving time and money in data entry and travel time; and how creating responsive, automated SMS communications systems can potentially empower communities to monitor programmes, contribute to data flows, and report on their progress. In time, a tool as simple to use as FrontlineSMS could be given to local organisations and even communities, to enable them to organise themselves to improve resilience. The potential for SMS in disaster preparedness has arguably only begun to be explored.

Combined effect of both Arctic and Antarctic sea ice variability on the summer monsoon rainfall over India with special emphasis on extremes

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KEYWORDS

Antarctic circumpolar wave
Mean meridional transport of heat
Indian summer monsoon rainfall

ABSTRACT

Polar sea ice is an important component in the global climate system through its modifying role in radiative, energy and mass exchange processes. The All-India summer monsoon rainfall (AISMR) that caters to the well being of over a billion people in the subcontinent is considered to be yet another significant and a well known global phenomenon. The sea ice data is obtained from the microwave sensors Scanning Multichannel Microwave Radiometer and Special Sensor Microwave Imager during the period 1979–2005. The sea ice extent (SIE) variability of Kara & Barents Seas (KBS) sector in the Arctic and the Bellingshausen & Amundsen Seas (BAS) sector in the Antarctic during boreal winter and austral summer respectively seems to have an influence on the overall behavior of AISMR. It is observed that the KBS SIE in the month of October is positively correlated (correlation coefficient = 0.5, significant at 99% level of confidence) with the subsequent AISMR. Whereas, the BAS SIE averaged over the months of October, November and December is negatively correlated (correlation coefficient = −0.47, significant at 98% level of confidence) with that of the ensuing AISMR. The polar sea ice linkage with the tropical AISMR comes through the mid-latitude forcing, namely, the Europe surface pressure anomaly tendency and the Antarctic circumpolar wave in the northern and southern hemisphere respectively. This study is aimed at understanding the combined effect of both the Arctic and the Antarctic sea ice variability on the performance of AISMR. Composite analyses of polar atmospheric and oceanic parameters show prominent features with respect to the extreme cases. Multiple linear regression analysis carried out using KBS SIE and BAS SIE as independent parameters provide results that give us confidence in using polar sea ice variability in both the hemispheres collectively as potential predictors for the long range forecasting of summer monsoon rainfall over India.

Community-based emergency medical care and disaster preparedness and child emergency medical care and disaster risk reduction in East Godavari district, India

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KEYWORDS

emergency medical care
school safety map/net
vulnerability
mitigation
disaster drills

ABSTRACT

CADME a coalition of 20 organisations working to mitigate the effects of natural/man made disasters. The actors involved are 28,412 children and 36,116 adults from 25 disaster prone villages and 25 vulnerable schools, district education department, district fire department, mandal revenue office, mandal development office, district fisheries office, 150 teachers from the 25 vulnerable schools, state disaster management authority, district women and child welfare department. This is a good practice, because: The project is a model to all the vulnerable communities in the country and children studying in vulnerable schools. Capacities of vulnerable communities are increased and confident of combating the disaster situations. Dependency on outside people, like Police, Medical teams, Military for rescue and Medical aid has been reduced drastically. Relief measures to be taken up in the event of disaster are taken care of by Taskforce groups, not depending on outside help. Able Bodied persons in vulnerable villages have specific responsibilities and actions in pre-during-post disaster situations. Women are very active and 50% of women are involved in each taskforce team. *What have been the key success/failure factors of this initiative?* All the 30 taskforce groups at village level are capacitated to combat the disaster situations (pre, during and post) with specific roles and responsibilities in each situation. Disaster drills are organized at regular intervals to familiarize them with their taken tasks and responsibilities. Contingency plans are updated every two months. Local bodies of each village have taken into consideration of the work done by task force group at their respective villages. Contingency plans developed by taskforce groups have been approved at local, mandal & district levels for spontaneous actions in collaboration with government officials for quick response. A joint taskforce committee consists of local task force and government officials at panchayat level, mandal level and district level have been formed to address the problems. What are the innovative elements and results? Cost Effectiveness: There is no need to purchase anything form outside to implement this initiative at vulnerable villages. Task force groups are well versed through the training and how to prepare the floating raft, using the local material like, gunny bags, damaged wooden flanks, waste glass bottles, and torned saris and so on. They are also trained to use waste cloth to be used as bandages for chin, knee head injuries and chest arm and leg fractures. They also construct a floating aid which can rescue two drowning persons with two plastic pots and a rope.

Women empowerment and reshaping disaster

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KEYWORDS
gender
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Uttarakhand

ABSTRACT

This impact of natural disaster and climate change is disproportionately affecting the livelihoods and security of the poor or downtrodden. Women comprise 70% of those living below the poverty line. As a result, they are most likely to bear the heaviest burdens when natural disasters strike. At the same time, women are often overlooked as potential contributors to climate change solutions, and thus to the security of all human beings. Recognizing and mobilizing their skills and capacities as social force and channeling it to enhance efforts to protect their safety and that of their communities and dependants is a major task in any disaster reduction strategy. Women in developing countries are already on the front line of adapting to climate change, with increasing floods and droughts impacting upon their livelihoods. As pivotal managers of natural and environmental resources and key frontline implementers of development, women have the experience and knowledge to build the resilience of their communities to the intensifying natural hazards to come. But without full participation and involvement of women in decision-making and leadership, real community resilience to climate change and disasters simply cannot be achieved. There are many examples of women's informal community involvement in disaster reduction. For example in Uttarakhand Hilly area women have proved their might and power in restoring back their forest property as well as minimizing the effect of natural disasters. Both deforestation and the introduction of a money-based economy into the hills dramatically dislocated Uttarakhand village communities. Furthermore, natural disasters are seen to increase in intensity as a result of deforested watersheds and destabilized geology. In several more actions at places such as Amarsar, Chanchnidhar, Dungari, Paintoli, and Badhyargarh, hill women demonstrated their new found power as non-violent activists. In 1977, Bachni Devi, ironically the wife of a contractor, led village women to save forest. The resultant empowerment of women dismayed many men, yet others grew to accept the new state of affairs. Their spirit in defense of the land saved the day. Their spontaneous grassroots activism eventually culminated in the banning of all tree felling above 1000 meters in 1980. The aim of this paper is to discuss women empowerment as source of adaptation, and provide women with opportunities to control greater percentages of resources (including land) and services and to make independent decisions.

Numerical simulation of the devastating super cyclone Gonu (2007)

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KEYWORDS
supercyclone
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ABSTRACT

The Super Cyclonic Storm Gonu 2007 was the strongest tropical cyclone on record in the Arabian Sea. Intense cyclones like Gonu have been extremely rare over the Arabian Sea, as most storms in this area tend to be small and dissipate quickly. The cyclone caused about $4.2 billion in damage (2007 USD), 50 deaths and 20,000 people affected in Oman, where the cyclone was considered the nations worst natural disaster. Gonu dropped heavy rainfall near the eastern coastline, reaching up to 610 mm (24 inches) which caused flooding and heavy damage. In Iran, the cyclone caused 28 deaths and $215 million in damage (2007 USD). Prediction of track and intensity of such devastating cyclones well in advance is necessary for disaster management purpose. In the present study numerical experiments are conducted to simulate the track and intensity of the super cyclone using Mesoscale Model MM5 with Two domains configuration (90–30 km resolution). Three experiments are conducted with variation in the cumulus parameterization schemes namely Grell (Gr), Betts–Miller (BM) and updated Kain–Fritsch (KF2). The forecast tracks indicate strong influence of cumulus parameterization schemes on the large scale steering flow. The observed movement of the storm is almost in the north-westward direction throughout the integration period. The track obtained from BM and KF2 experiments show northward movement initially and then recurved in north-eastward direction after 48 hours of integration. It appears that translational speed of the storm is slower in the case of BM and faster in case of KF2 compared to observation. Only Gr could simulate the track in the north-west direction which is close to the observed track (i.e. IMD). But all the three schemes underestimated the intensity. Further to study the sensitivity to the level of nesting two more experiments are conducted one with 3 domains configuration (90–30–10 km resolution) using Gr cumulus scheme and another with 4 domains configuration(90–30–10–3.3 km resolution) with no CPS on 3.3 km domain and Gr of rest three domains. The track seems to be less sensitive to the level of nesting but intensity forecast is improved with higher nesting level. The 4 domains configuration in which fourth domain with 3.3 km resolution is set to be moving with the storm gives the simulation of intensity of Gonu comparable with the observation. The results suggest that it may be possible to predict track, intensity and inner-core structures of devastating tropical cyclones with the help of high grid resolution and realistic model physics configuration.

Psychological support and mental health: Findings from cross-cultural research

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KEYWORDS

psychological support
resource losses
cross-cultural research
stress theory

ABSTRACT

'We know little about how culture shapes the psychological impact of disasters', writes disaster researcher Fran Norris. There is a 'critical need' for research to examine psychological support and mental health following natural disasters around the world. Further, '. . . too few studies exist to even begin to extrapolate general principles' (Norris, 2005). Do people in different regions experience similar distress symptoms? How might cultural and contextual factors such as geography influence preparation for and responses following disasters? This paper examines recent research conducted by the author that examines mental health and psychological support following disasters around the world, including the 2001 Gujarat, India earthquake, the 2004 Indian Ocean Tsunami, and the 2006 earthquake in Yogyakarta, Indonesia. The projects were guided by the conservation of resources stress theory (Hobfoll, 1989; 2002). The theory identifies four categories of resources: condition (e.g., marriage, employment, or other social roles), personal characteristic (e.g., age, knowledge, locus of control, self-esteem, skills), energy (e.g., money, insurance), and object (e.g., house, car, or other physical possessions). These resources are vital because they help people survive, provide meaning in their lives, and help people acquire or maintain other resources. Societal and cultural factors influence the type and quality of resources that people value and obtain. The theory predicts that psychological stress occurs when there is a *threat* of resource loss, *loss* of resources, or *lack of resource gain* following investment of resources (Hobfoll, 1989; 1998). The theory also predicts that resource gains following a stressful event may have positive effects on subsequent coping. For example, survivors may learn problem solving skills, develop an enhanced sense of self-efficacy, and have stronger bonds among family members (Linley & Joseph, 2004; Sattler, 2003; Tedeschi & Calhoun, 2004). Social support provided by friends and family also can play a vital role in helping people cope with tragedy (Kaniasty & Norris, 1995). Implications of the findings for disaster interventions are discussed.

Community participation and education — Community based disaster management and public awareness

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KEYWORDS

effectiveness
knowledge
disaster
disaster preparedness
residents
apartment building
awareness program

ABSTRACT

The role of communities and individual families in taking appropriate action to mitigate the impacts of disasters has been emphasized to the local government. The increased occurrence of small and medium scale disasters has resulted in the concept of Community Based Disaster Management which is a new approach to manage disasters through people's participation. The incidents took place in Bengaluru over recent years and Government of India's Disaster Risk Management Program and National Disaster Management Act influenced researcher to conduct 'A study to assess the effectiveness of awareness program on disaster preparedness among residents of selected apartment buildings in Bengaluru South'. Objective of the study was to assess the existing knowledge, the existing safety measures regarding disaster preparedness, develop and conduct an awareness program, compare pre test and post scores and find out the association between level of knowledge on disaster preparedness and demographic variables. A quasi-experimental study was conducted using pre test and post test with control group research design. Purposive sampling technique was used to select 200 residents from each group. Data was collected by using structured interview schedule and observational checklist. In this study majority of respondents were in the age group of 19–28, gender males, being graduates and professionally they were engineers. Majority of the respondents did not experience any disasters in their life and obtained information on disasters through different mass media. More than 60 percent of respondents did not have any training on disaster management. In the pre test 66 percent and 78 percent of respondents had moderate knowledge regarding disaster and disaster preparedness in experimental and control group respectively. In this study there were inadequate safety measures available at the apartments to prevent and face the disasters both in experimental and control group. The mean percentage score in pre test of control group was 60.05 percent against 59.15 percent of mean scores in experimental group. After awareness programme, in the post test the mean scores of experimental group was 77.8 percent. The mean difference in the pre-test and post-test scores in the experimental group was 18.65 percent which was statistically significant, however difference between pre-test and post-test in control group was 1.7 percent which was not statistically significant. Only in experimental group there was significant association between information and knowledge. Majority of the participants are between the age group of 19–28 years, graduates and professionally engineers. There were inadequate safety measures available at the apartments to prevent and face the disasters. In the post test score of experimental group there was 18.65 percent mean enhancement observed and there was significant increase in knowledge scores ($t = 2.715*, p < 0.05$). There was no significant change observed in control group. Hence awareness program on disaster preparedness was effective.

Disaster governance and survivability of victims: an Empirical analysis

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KEYWORDS

disaster governance
Kollam
CRZ

ABSTRACT

Disaster strikes the normal life and then governance. Often, disaster unearths the flaws in administrative structure. The affected community often wants the governance in its full capacity. Capacity does mean capability to demonstrate 'welfare mode' of state. In every disaster the survivors expect the unbiased and 'right based' mitigation approach, hence, post-disaster effects would have significant role in understand the nature of governance. The application or imposition of legal regulations and development policy are having multi faced recipients in disaster affected areas. Unlike other zones governance in post-disaster areas does not have a passive generality. Though it has receptive beneficiaries it does not mean that, they are pro-active. Often, the pre-disaster eco-social relations play as a control group in governance and the economic expectations as well. Hence the issue of rehabilitation hardly poses higher financial responsibility to the state. This paper discusses this issue in detail, by taking post-tsunami rehabilitation process in two villages of Kollam district of Kerala. The paper critically examines the nature of governance in the post-tsunami phase especially in connection with the implementation of Coastal Regulation Zone regime and non-governmental agencies involvement.

Informal sector water-utility management: Potential urban-slum upgradation policies in Bangladesh

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KEYWORDS

informal sector
water-utility management
urban-slum
adaptable
upgradation policies

ABSTRACT

The unplanned water sector of slum settlements in many developing countries has an enormous backlog in the provision of reliable water supplies and sanitation services to its population, which is further exacerbated by the growing number of informal settlements. Development policy agendas are needed to be reshaped in ways that de-emphasize central state control and that shift responsibilities to local government, NGOS and the market. With some extensive literature review and using the outcomes of some studies on slum upgradation and its infrastructure development, this paper shows a range of practices and policies in accessing water and sanitation to urban slum settlements. The paper also summarizes the findings of the effectiveness of different policies and also discusses the difficulties and limitations of implementing government and private organizations initiations. It identifies the changes needed to make slum upgrading more effective and capable of reaching a much larger scale. It starts from the observation of supply and provision of water and sanitation of slum as well as various upgradation program and policies. This research is concluded outlining a conceptual statement of adaptable slum up gradation policies in the context of developing countries.

A study on the human and psychosocial factors contributing to industrial accidents

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KEYWORDS

unsafe action factors
psychosocial factors
personal factors

ABSTRACT

The human factor is very important for the achievement of the objectives of any organization without accidents. The human with his ability to feel, to think, to conceive and to plan is most valuable in the prevention of industrial accidents. The objective of this study is to know the causes of accidents due to human errors, and understand the importance of human behaviour, psychology and its role in preventing accidents.

Integration of public administrative infrastructure for effective disaster management

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KEYWORDS
disaster administration
irrigation
CBDM

ABSTRACT

This paper aims at examining the scope of utilizing existing public administrative infrastructure system for effective disaster management, and attempts to generate a dynamic model. It is necessary to classify disasters based on the area of occurrence and the type or genre. A landslide may occur in a remote, inaccessible hilly village terrain whereas tsunami hits along coastal areas where there would be roads. Season is another important aspect. For example, at the onset of southwest monsoon devastating floods cause damages to life and property. In the case of seasonal disasters the type of disasters that could happen can be anticipated to some extent, except the exact location and its timing. Time and day is another factor which has no bearing on disaster occurrence. There is no guarantee that on a Sunday or any other holiday a disaster will not occur. The speed of flow of information and its direction during disaster management needs to be cohesive which often is not. Presently disaster management is the responsibility solely of Revenue department with the support mainly from police and health departments depending upon the type of disaster. Many other major departments which can effectively contribute to this process are not made to participate for no reason. What is identified is that idling or underutilization of efficient, trained, skilled human resource in various departments happen in the case of disaster management. It is necessary to change this system for the better. The expertise and the organizational functioning method vary from department to department. The task of unifying these diverse but strong positive forces is herculean. Assigning or/and delegating powers to different ranks of officers in various departments would be necessary in disaster management. The organizational setup of different departments being different, directing a group of officers for a particular task demands more understanding of the public administration system. In addition to the Revenue Department which would be at the helm, other departments like PWD, IRRIGATION, AGRICULTURE, EDUCATION etc can be intertwined with this process. Use of static infrastructure like schools, community halls etc for rehabilitation, mobilizing the available vehicles attached to different departments etc for instance can impart speed and effectiveness to rescue operation. Decentralized governance has brought positive changes in management of activities at grassroot levels. The reach of panchayat raj institutions is a good attribute for utilizing their infrastructure capabilities in dealing with disaster management. The leadership qualities inherent with various political organizations functioning in the geographic limits of panchayat raj institutions can also be directed towards disaster management. Interlinking of modern communication technology and devices to the existing system demands a detailed and comprehensive idea of the machinery of different departments. This paper aims at evaluating the modus operandi presently resorted to by public administration in disaster management, and tries to identify the key requirements for effective and optimum utilization of the available infrastructure. Thus it attempts to generate a new dynamic model involving a matrix of departments. The infrastructure in this context means both human resource and the static, mobile and communication infrastructure. The geographic control space shall be taken as a revenue district.

Community-based disaster management and public awareness

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KEYWORDS
CBDM
NGO

ABSTRACT

The government of India constituted a 31 member committee headed by J C Pant in 1999 and the committee in its report identified 31 types of disasters under five categories such as water and climate related disasters, Geologically-related disasters, Chemical, Industrial and Nuclear related disasters, Accident related disasters and Biologically related disasters. When a hazard causes massive loss of life and property, it is referred as Disaster. It is a serious disruption of the functioning of a society causing widespread human, material or environmental losses. The loss is such widespread that the existing available local resources cannot fulfill the damage or losses caused by disaster. The paper consists of four sections and the first section deals with the introduction with back ground and rationale. The second section deals with the past experiences which reveal the fact that the pre and post disaster management strategies can be carried out effectively only with peoples participation and public awareness. Community based disaster management programs helps to prepare people and respond to disasters and recover from emergencies. The need for coordination between different government departments, local bodies, volunteers and NGOs with the people. The third section deals with community based mitigation measures and disaster preparedness. The definition and meaning of the term mitigation which applies to a wide range of activities and protection measures, from the *physical*, like constructing stronger buildings, to the *procedural*, like standard techniques for incorporating hazard assessment in land-use planning. The need to evolve a culture of preparedness among the people through public awareness is carefully discussed. The fourth section deals with strategies that can be adapted during and post disaster situations like rescue, rehabilitation and development with complete participation of community. Few experiences learned from the Gujarat earth quake and 2005 Tsunami in all the phases like rescue, relief, rehabilitation and development are explored to substantiate the argument.

Challenges and opportunities in managing humanitarian logistics inventories during mass emergencies

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KEYWORDS
logistics management
humanitarian support
relief
disaster management software

ABSTRACT

A major challenge before the administration during every disaster situation is the sustained management of logistics operation in accordance with the necessities of the affected community. Logistics support in response and relief phases puts thrust on the mobilisation of emergency services to maintain life as well as to socially support the affected communities by facilitating access to the basic needs of the people during and immediately after the disastrous event. The structure and functions of logistics management depends on the type, intensity, magnitude and impact of the disaster and the success of the entire relief operation may hinge upon the timely provision of supply and services. Acquisition and storage of relief materials to a central repository, its distribution to intermediate storage and further redistribution to relief camps requires adequate human resources with higher levels of management and quantitative skills. This paper reviews the challenges in humanitarian logistics distribution and the need for advanced technological developments in managing disaster response and logistics operations. The use of technological support in relief operations can make significant improvements in making smooth the complex process of information exchange and services management. Development of service-based software, its availability and promotion at different administrative and operational levels are discussed as part of the review to suggest best practices and user-friendly interfaces.

Objective approaches for landslide susceptibility zonation in western Himalaya

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KEYWORDS
LaSaRiZ
Himalayas
Landslide susceptibility

ABSTRACT

Availability of accurate and objective landslide susceptibility maps depicting zones defined on the basis of probability of occurrence of landslides is one of the critical inputs in assessing risk to property and lives in any mountainous region, particularly in the Himalayas. The aim of this study is to evaluate the potential of three objective approaches, namely, artificial neural network, fuzzy set theoretic and a neuro-fuzzy approach for landslide susceptibility zonation. The efficacy of these was examined in a landslide prone area in the Chamoli region of the Western Himalaya. An in-house software, with acronym as **La**ndslide **S**usceptibility **a**nd **Ri**sk **Z**onation (LaSaRiZ), was developed for landslide susceptibility zonation and risk assessment. Seven causative factors, namely, slope, slope aspect, relative relief, lithology, structural features, land use land cover, and drainage density, were considered. The results from the software indicate that LSZ map based on combined neural network and fuzzy approach performed exceedingly better than those produced from neural network black box approach and fuzzy relation based approaches. The landslide density values from this map clearly showed the close agreement of the susceptibility zones with actual field conditions.

Prediction of end of break/active phases of summer monsoon over India

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KEYWORDS
break monsoon
summer monsoon

ABSTRACT

India receives approximately 80% of annual rainfall during southwest monsoon and it is the key factor which affects the economy of the country. To know the interruption of monsoon by prolonged spells of sparse rainfall (break monsoon) during the mid-monsoon months of July and August over India is of vital importance. With this aim, present work has been carried out. The study brings out that after initiation of break (active) phase over India, total rainfall amount and its areal coverage over China increases (decreases). Time when it start decreasing (increasing), after attaining highest (lowest) values; marks the beginning of end of break (active) phase. The study certainly gives some clue about the end of break/active phase, although it does not give any signal of initiation of break/active phase. Departure in days of end of break/active phases from study and as reported is in the range −2 to +2 (except 3 cases out of fifteen) for breaks and 0 to −3 for active phases (except one case). Study points out that the highest rainfall over China remains more than 90 cm for break phases and the lowest rainfall remains less than 70 cm in active phases.

Women leadership in disaster management: A lesson learned from past

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KEYWORDS
gender
leadership
disaster risk reduction

ABSTRACT

The experience and impact of increasing frequency and intensity of floods, cyclones, droughts and salinity intrusion is gender neutral. But the question of adaptation and coping with respect to the changing nature of disasters are often remarked as gender biased. As because the rural women have far-reaching consequences on their human security issues, i.e. lives, livelihood, food and nutrition, physical and physiological protection, thereof women are viewed as a vulnerable group rather than active agents in risk reduction and adaptation. Over the years there has been a shift into the community's perception of the role of women. Evidence suggests that communities are now more ready to accept women leading their disaster risk reduction. Women are now involved in local disaster management committees formed within local government system. They also play a lead role in the NGO-led disaster committees at local level. However, the unaddressed specific vulnerabilities of women that form a barrier must be addressed before women can play a meaningful leadership role at the community level. Since, the role of these committees is limited in pre and post-disaster decision-making, women's economic contribution continues to be an overlooked area in economic planning as well as disaster assessment. As a result, they do not get a fair share from the post-disaster assistance. From this ground this paper explains some facts and thoughts of existing micro-level good practices those promote women leadership in disaster management.

Kerala fire & rescue services and its role in crisis management

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KEYWORDS
fire
rescue
crisis management

ABSTRACT

Kerala Fire and Rescue Services Department came into existence by the enactment of Kerala Fire Force Act 1962, (Act 20 of 1962) issued in Government Notification No.9018-E1-61/LAW dated 21.6.1962. It comes under State Home Department. It is a small department with a total staff strength less than 4000. The superintendence and control of the Kerala Fire and Rescue Services Department is vested with the Commandant General. Head Quarters of Kerala Fire & Rescue Services is at Thiruvananthapuram. For administrative convenience, the activities of the Department are put under the charge of five Divisional Officers with headquarters at Thiruvananthapuram, Kottayam, Ernakulam, Palakkad and Kozhikode. The Officer in charge of Fire and Rescue Stations in the district is Assistant Divisional Officer. Each Fire and Rescue Station comes under the direct charge of Station Officer. The primary duty of the Kerala Fire and Rescue Services Department is to save the life and to protect the properties from fire, accidents, and other calamities. As we all know service of Fire & Rescue Service is solicited in by lay man to highest officials in case of emergency. Service ranges from lift rescue to animal rescue, fire fighting in simple carbonaceous fire to complex aircraft fires and standby or escort duties during VVIP visits. Awareness creation is an area where Kerala Fire & Rescue service plays a key role. This Department organises training classes and mock drills, in association with government departments and non-governmental organizations. One major stake holder in this aspect is the Institute of Land and Disaster Management (ILDM), Thiruvananthapuram. Most valuable resource of any service is its personnel. Fire service is not an exception. But the personnel cannot perform effectively without necessary equipments. Fire fighting and rescue are collective work which requires disciplined human resource, trained to handle equipments. Training is imparted in handling casualties. The statistics regarding the life saved (human as well as animal) and the value of the property saved from fire during the past five years gives a clear picture about the relevance of this department. Human lives saved comes to 4493, animal lives saved 1390 and the value of the property saved about Rs.1131.15 crores. Fire & Rescue Service is not profit-oriented. Fire fighting and rescue operations are done free of coast. Free as well as paid ambulance service, pumping works, standby etc forms part of duty. There is a need for equipping the department with modern gadgets and techniques. In India terrorism has assumed serious dimensions after the Bombay attacks. This coupled with other factors like vertical development and growth of chemical industries has brought in new challenges to fire fighters and rescuers. This necessitates induction of new equipments for the purpose of fire fighting and rescue. Use of modern PPEs (Personal Protective Equipments) is an area of interest nowadays. In any crisis society at large in the immediate vicinity is the first responder. In disasters where the normal functioning of society itself collapses, the only agency for rendering help and support is Fire and Rescue Service. Its role in Kerala is crucial as it is the only organized emergency operational agency available in the state, capable of handling disasters in the changing scenario.

Numerical simulation of Severe cyclonic storm LAILA(2010): Sensitivity to initial condition & cumulus parameterization scheme

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KEYWORDS

cyclone
LAILA
cumulus parametrization

ABSTRACT

The cumulus processes play an important role in predicting the track, intensity and inner core structure of the tropical cyclones. Its adequate representation becomes one of the most challenging tasks in mesoscale numerical simulation and prediction. The present study explores the sensitivity of initial condition and cumulus processes on the numerical simulation of Severe cyclone LAILA (May 2010, maximum surface wind of 55kt and lowest central pressure of 986 hPa as per observation) during pre-monsoon season over Bay of Bengal. Mesoscale Model WRF with two two-way interactive nested domains at resolutions of 60 km, 20 km is used. Total 8 experiments are conducted using KF, BMJ, GD and new Grell as cumulus schemes and 00UTC of 16^{th} May (observed state- no disturbance) & 00UTC of 17^{th} May (observed state- low pressure area) as two different initial conditions. GFS data of $1^{\circ} \times 1^{\circ}$ degree resolution is used to initialize the model and to provide time dependent boundary conditions to the model. The model fields are verified against the best estimated track of cyclone provided by IMD. Even though the initial conditions are changed, GD & new Grell schemes are not able to produce the circulation. It is found that BMJ scheme produces less track error compared to KF scheme (KF shows northeastward movement). The track error is reduced when the initial conditions are supplied prior to formation of low. Intensity of the cyclone LAILA is found to be closer to the observations when integration is started on 16^{th} May rather than 17^{th} May. The simulated dynamic and thermodynamic structures (for both 16^{th} May & 17^{th} May) at the mature stage, in the present study are found to be comparable with the earlier reported theoretical and observational studies of cyclone. WRF model shows improved results when integration is started before any disturbance i.e. on 16^{th} May.

Emergency planning in a hazardous chemical facility — A tool for effective disaster management

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KEYWORDS

chemical disasters
emergency planning
hydrogen sulphide

ABSTRACT

India is spearheading towards a rapid expansion of hazardous chemical industries be it, petrochemical, fertilizer, heavy chemicals, pesticides, pharmaceuticals etc which involves handling, storage, transportation and processing of chemicals. The safety in these activities is of prime concern. The consequences due to release/discharge of chemicals in any form (liquid, vapor, gas, smoke, dust or any combination of these) from the industry into the public domain attracts attention of media and cause panic to public. The Bhopal accident has changed the attitude of the government, plant managements and the administrative machinery from relief, rescue restoration and rehabilitation approach to prognostication, prevention, planning and preparedness with respect to hazardous industries. The facility under our study is a hazardous chemical processing industry involved in manufacture of heavy water, a prescribed substance used in the production of nuclear power in India. The hazards foreseen in this facility are of chemical nature. The stipulated safety criteria for the hazardous facility are ensured by strict regulatory controls. The process essentially contains production of a toxic, flammable and corrosive gas namely hydrogen sulphide gas through chemical double decomposition. The hydrogen sulphide gas is utilized for the bi-thermal chemical exchange with and enrichment of natural water to produce reactor grade heavy water. The inventory of the hydrogen sulphide gas in the facility would be maximum 400 tons. The facility stores, handles and processes the hydrogen sulphide gas at various stages of production process. The safety of the plant, public and the environment is given due consideration right from the siting stage of the facility and it is ensured during the progressive stages till regular operation. The safety features are engineered in the design for the safe operation of the facility. The probable emergency release scenarios of the hydrogen sulphide gas are identified. The various types of emergencies like Plant emergency (affecting plant areas only), on- site emergency (affecting the entire plant site) and Off-site emergency (affecting the areas in public domain) are envisaged. The emergency plans for mitigating the emergencies cited above are well laid out. The emergency planning process involves, zoning around the plant - exclusion zone (buffer area of about 1.6 km radius with greenery only) and sterilization zone (population controlled area of about 5 km), methods available for detecting leaks/gas releases, criteria for actions based on levels of gas detected through detectors placed at facility site, modes of declaration and termination of emergency through sirens, actions of facility personnel, identified responsible agencies of facility and local administration, action plans for all agencies, emergency resources (breathing apparatuses, emergency shelters, antidotes, communication systems, transport, etc). The preparedness for emergencies is ensured through periodic emergency exercises and mock drills involving facility and local administration officials. AERB as a regulator oversees the effectiveness and efficacy of the emergency plans and preparedness.

Disaster risk management in chemical industries — A case study

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KEYWORDS

chemical disasters
combination effect
ammonia

ABSTRACT

There have been considerable changes with respect to the frequency and intensities of natural hazards. The impact of these natural hazards on the chemical industries handling highly hazardous chemicals is significantly high and has the potential for '**combination accidents**' for example, triggering of chemical disaster, fire disaster etc. due to flood/earthquake disaster. The consequences of such disasters are very severe, both in terms of financial losses and safety of employees & public. In view of the above, the disaster management in hazardous chemical industries has become of significant importance. The paper highlights the consequences of floods and the precautions to be observed in case of flood emergency in a chemical industry with a case study of a flood incident at Ammonia based chemical plant at, Hazira, Surat. The safety issues that surfaced from the incident and the mitigation measures have been highlighted. Paper also suggests the application of 'Risk Assessment Techniques' for identifying hazards from such natural hazards triggering industrial hazards and incorporating mitigation measures in design stage, thereby aiding in formulating effective & efficient 'Disaster Management Plan'.

Resettlement and rehabilitation project implementation and its outcomes in Orissa: Case of TATA steel, Kalinganagar project and UNDP support for Government of Orissa

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KEYWORDS

R&R project in Orissa
participants' perceptions
local framework
Government policy

ABSTRACT

The study Resettlement and Rehabilitation project implementation outcomes concerns on the challenges of TATA Steel in Kalinganagar project and UNDP technical support for Government of Orissa in various R&R projects, while targeting to enhance livelihood options and quality of life of the rehabilitants. In 2008 data and information have been gathered to apprise the quality of life, market feasibility and policy implications at Sansailo Trijanga-I and II by three students of rural management, KIIT University and in 2009 one student has gathered data on the status of the R&R project intervention in Angul industrial belt and Jajpur in Orissa under the technical support of UNDP. Follow up fieldwork has been done by the author. Individual interview, stakeholders' opinion and case studies shed light on the outcome and challenges for the technical support team of UNDP, Tata Steel and Government of Orissa. Using insights drawing on field experience in R&R Orissa this study argues that consideration of active participation can contribute significantly to an understanding of rehabilitant's subjective perceptions and values towards the quality of life. This study emphasize that alternative livelihood options and its marketability and income will be possible by enabling people's active participation to design, implement and follow up appropriate business plan, housing and capacity building within a strategic community framework.

Challenges in managing e-waste in India

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KEYWORDS

extended producer responsibility (EPR)
e-waste
product take-back

ABSTRACT

The developing countries are facing a huge challenge in the management of electronic waste (e-waste) which are either internally generated or imported illegally as 'used' goods. E-waste contains hazardous constituents that negatively impact the environment and human health. In India, because of lack of adequate infrastructure to manage wastes safely, these wastes are buried, burnt in the open air or dumped into the surface water bodies. We should have in place legislation mandating electronic manufacturers and importers to take-back used electronic products at their end-of-life (EoL) based on the principle of extended producer responsibility (EPR). This paper gives an insight into various forms and the quantum of e-waste in the Indian scenario, the source and the circulation routes, the nature and the amount of toxic and valuable constituents of e-waste, potential pollution threat to environment, recycling methods, efficient management techniques for e-waste, awareness of people and legal requirements.

Response of international charter space and major disasters to major disasters

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KEYWORDS

charter
disaster
flood
cyclone or hurricane
forest-fire
volcano
oil-spill

ABSTRACT

Space based Disaster Management System has the distinct advantage of being unaffected by disasters on the ground and provides unbiased, synoptic and timely information on the nature and impact of the disasters. Indian Space Research Organization has developed several applications/programs and techniques with the space imagery to support disaster management. Further, ISRO is a signatory to the International charter 'Space and Major Disasters' along with space agencies of Canada (CSA), Europe (ESA, CNES, DMC), USA (USGS, NOAA), Argentina (CONAE), Japan (JAXA) and China (CNSA). Recently space agencies of Germany (DLR) and Brazil (INPE) have joined the Charter and are in the process of getting integrated into Charter operations. International charter 'Space and Major Disasters' is the maiden initiative of this kind, in which, space faring nations formally participate to pool their space and ground segment resources and deliver data in emergency situations. This paper brings out the objectives of International charter 'Space and Major Disasters' its operational organization, support mechanism and application for major disasters such as Flood, Cyclone or Hurricane, Forest-Fire, Volcano and Oil-spill. ISRO plays an active role in the charter functioning by sharing secretariat, Emergency on Call Officer and Project Manager Support services, and a brief account of ISRO's participation in the charter operations is provided. Charter has been active since 2000, providing useful service to humanity during major disasters all over the globe. Performance of the charter thus far, with illustrative case studies of selected charter activations is included. The kind of response the Charter received from the user agencies from all around the world once again established its significance and role for major disasters and its wider user base.

Role of NGOs in disaster management

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KEYWORDS

NGO
Red Cross
accidents

ABSTRACT

Disaster Management plays a vital role in India's policy frame work. The poor and under privileged are worst affected due to calamities as well as Disasters. Disaster needs a special attention during pre-disasters besides relief and rehabilitation phases. It is matter of sorrow that every year in India about 125000 persons die in road accidents and one third part of the nation's budget is being spent on accidents. In India, in every six minutes one person dies in Road accidents, over 17 million non-fatal injuries occur every year in work places which are serious enough to make people miss work and more than 45,000 workers suffer from fatal injuries on the job every year. In Haryana & Punjab about 4,500 & 4,000 persons respectively are dying in road accidents. There are so many other NGOs working in the area of Disaster Management. International Committee of Red Cross and National Societies of Red Cross are playing vital role with dedicated filed operation and resource backup. **Red Cross** provides its services in three phases Pre-Disaster, During Disaster and Post-Disaster. In the Pre-Disaster, awareness and training programmes are most important to reduce the risk of disaster and to work for rehabilitation and recovery in Post-Disaster phase and also to reduce the mortality rate during disaster. In this respect, it is important to know that St. John Ambulance (India) through its State & District Branches imparting First Aid training for the factory workers, Drivers, Police Personnels, Home Guards & Civil Defence Personnel, Students of Universities & Colleges as well as General Public. The details of the trained First Aiders always remain with the respective State/District Branches of the St. John Ambulance as well as National Headquarters. During Disaster so many persons die in absence of proper handling and timely help does not reach the affected/maimed persons. The services of the First Aiders can be utilized as they are the key persons to provide First Aid in a systematic way. They are trained to transport the casualties and in helping the medical staff. National Disaster Management Authority, Govt. of India should take the services of First Aiders through St. John Ambulance (India). It is also a need of time that First Aid must be a compulsory subject in schools, colleges & other professional Institutions and a Lecturers of First Aid should be appointed as Instructors through St. John Ambulance. During the Disaster phase, they can also provide technical support for safe construction, restore means of livelihood and can assist Government in monitoring Disaster Management Programmes. The First Aiders can also motivate the Local Resident Welfare Associations, Local Bodies, Panchayati Raj Institutions, Nehru Yuva Kendra Sangathan, National Service Schemes, Religious Bodies, Educational Institutions and these may be made trained for three phases of Disasters. It is also suggested that NDMA should prepare a clear guidelines that the First Aid should be compulsory for all the citizens of India so that immediate First Aid can be provided to the injured persons. The emphasize should be given on the vehicle holders either two, three or four vehicles as training of First Aid should be mandatory for these persons before issuing the Driving License like Drivers and Conductors of Transport Deptts. The St. John Ambulance should be the Nodal Agency for imparting & evaluation of the Training Programmes. Thus we can reduce the risk reduction like fatal of the road accidents.

Effectiveness of gender mainstreaming in disaster risk reduction

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KEYWORDS

gender mainstreaming
disaster
risk reduction strategies

ABSTRACT

Disasters are complex and quintessentially social events, reflecting not so much uncontrolled brute forces as the interaction of hazards and natural events with social structures and political communities. Women in developing countries are the most vulnerable sections of our society. Disasters affect women and men differently, and due to deep-seated gender inequalities, women are at greater risk of suffering from disasters (Enarson, Elaine and P. G. Dhar Chkrabarti, 2009). In view of the fact that women are more vulnerable in a disaster, their needs and concerns should be widely incorporated into risk reduction plans and strategies should be evolved from both perspectives of women as beneficiaries and decision makers. Commonly women are given least importance in risk reduction strategies. To promote the involvement of women, both as beneficiaries and decision makers, gender mainstreaming in disaster reduction policy making is considered an important element. Gender mainstreaming in disaster reduction refers to promoting awareness about gender equity and equality in disaster management. Thus, incorporation of gender analysis in disaster management and risk reduction helps in reducing the impact of disasters and thereby decreases the vulnerability of women contributing to sustainable development. Gender perspective should be included in the following components of risk assessment, early warning, information management, and education and training, etc. This paper aims to study the gender issues in disaster management and tries to look at the best practices of disaster management that had incorporated gender concerns in its application. This paper would further look at the challenges faced by women in disasters and suggest measures to achieve equal participation of women in decision making. Thus this paper would highlight the approaches that integrate gender perspective into disaster reduction strategies, thereby suggest changes in policies and practices that are necessary for mainstreaming gender in the Indian context.

Disaster risk communication over early warning technologies — A case study of coastal Kerala

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KEYWORDS

early warning
disaster
cyclone

ABSTRACT

Kerala has a long coastline with a length of 580 km which is vulnerable to various types of coastal hazards like storm surge, coastal flooding, sea erosion, tsunami, and cyclone. The impact of climate change can be manifested in these coastal hazards with the exposure sea level rise and is expected its intensity to be severe in the coastal area of the state in the coming years. It may add vulnerability of the states social and economic structure as coastal area of the Kerala which is one of the most densely populated regions in the country, with a population density of 2022 as against 819 for the state average (Census, 2001). Also most of the urban agglomerations are concentrated in the coastal belt including 5 municipal corporations and more than 75% state GDP contribute economic activities located in the coastal area of the state. Complex social, demographic, economical and environmental vulnerability and hazardous nature may turn coastal area of the state into a risky situation by increasing chances of various disasters. Disaster Risk Reduction and Management activities may reduce from the negative consequences of the occurrences of the various natural events in the coastal areas. Timely disaster communication through various early warning techniques plays a crucial role to reduce disaster risk in the coastal area. It can be done through timely prediction and dissemination of early warning to the vulnerable communities. Timely prediction of the occurrence of most coastal hazards is almost possible at this point of time with help of advanced science and techniques. Last mile connectivity methods including Very High Frequency Radio, Satellite based radios, DTH services; Incois Digital Board etc can be used to reduce exposure of the risk caused by the various hazards through timely disaster communication. In spite of these achievements in the field of information and communication technologies, still large numbers of vulnerable communities do not receive timely warning in a disaster situation. Thus early warning of communication or dissemination to the most vulnerable population is a serious challenging task in disaster risk reduction and management. Based on these experiences, Government of Kerala has established State-wide Early Warning System cum Communication Network with support of United Nations Development Programme under DRM Programme and Asian Development Bank under TEAP Programme. The system is Very High Frequency (VHF) technology, well known for Alternative communication at all types of needs in disaster point of view. This may be most accurate technology in the state through to disseminate warning to the vulnerable population in the hazard prone areas. Hence, Disaster communication over Early Warning Technologies can be a crucial part in a disaster risk management for the hazard prone areas of the coastal Kerala. This paper describes available opportunity to disseminating timely disaster communication over VHF technologies in a disaster situation to vulnerable coastal region of Kerala

Landslide prediction mapping using geoinformation techniques

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KEYWORDS

landslide
geographic information system
remote sensing
disaster

ABSTRACT

Landslides occur in a large variety of forms depending on the type and speed of movements, the material involved and the triggering mechanism. The study was undertaken in the Idukki district of Kerala characterized by highly undulating terrain with steep slopes. A spatial database was constructed from topographic maps, geology and land cover. Land cover was classified from IRS LISS III satellite imagery. Frequency ratio models were done for the preparation of landslide hazard zonation mapping and the field data compared statistically. The prepared landslide zonation map was overlaid by field landslide data and combined together to prepare landslide prediction map. The landslide susceptibility map classifies the area into four classes of landslide susceptible zones i.e., very high, high, moderate, low and very low. Based on the landslide zonation map landslide prediction map was prepared. The accuracy of landslide prediction map was verified by field investigation using GPS.

Multiple hazard mapping in block level using geoinformation technology

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KEYWORDS

hazard
GIS
zonation map

ABSTRACT

Natural hazards, the physical events of natural processes, can be considered as negative resources that alter/degrade the environment thereby affecting a large human population. The main purpose of multiple hazard maps is to gather together in one map the different hazards related information for each district to convey a composite picture of all the natural hazards. It also becomes a comprehensive analytical tool for assessing vulnerability and risk at the village level, an essential input to a planner. The present study develops different hazard zonation mapping using gis and remote sensing techniques. In this study village level information was collected based on field investigation and landslide zonation map, drought hazard map, fire hazard map, flood hazard map prepared. The study is of use in better preparedness and disaster management.

Drought hazard mapping in Chinnar Wildlife Sanctuary using GIS and remote sensing

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KEYWORDS

drought
GIS
wildlife

ABSTRACT

Remote sensing and geographic information system have significantly aided identification of drought vulnerable areas in the recent past. Drought is one of the natural disasters having an impact on both the economy and the society, with its long-standing problems. Drought by nature is a result of inter-related parameters. The study is based on the concept that the severity of the drought is a function of rainfall, hydrological and physical aspects of the landscape. In the present study a Geographic Information Systems (GIS) and remote sensing based tool for drought vulnerability assessment at a micro level has been developed. The present study identified drought prone areas of the Chinnar wildlife sanctuary in the Idukki district in Kerala. The Chinnar wildlife sanctuary falls in the rain shadow region of Kerala. The final map shows different zones of drought vulnerability ranging from low, medium, high and very high.

Gender analysis in disaster risk reduction through local planning and budgeting process in Bantul regency, DIY Province, Indonesia

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KEYWORDS

gender
disaster risk reduction
planning budgeting process

ABSTRACT

Disasters that have been happened in Indonesia has given the hard earned lesson that disaster risk reduction must be a basic ingredient in the government planning policy. A key factor in disaster risk reduction is ensuring that gender analysis is integrated. Related to the local planning and budgeting process, it is important to analyse the impact and do a vulnerability analysis, stakeholder relation analysis, and finally to have women in positions of decision making in for local planning and budgeting. As the most solid and concrete policy product of the executive and the legislative, the budget can increase or even sustain gender bias. A gender sensitive local planning and budgeting process that uses disaster risk reduction perspective will encourage gender welfare and gender equity in development process. The problems related to local planning and the budgeting process are the limited participation in budgeting, especially of women and other gender minority, budget policy that does not consider the prevalent gender bias. That makes the argument for a budget arrangement that uses a gender-neutral approach. The most important thing is that disasters directly impact women. Moreover, women's participation in the process of policymaking, particularly budget, can be a medium for women to be involved in the development, and finally they are encouraged to struggle for safeguarding interest. In fact, the long-term impact of disasters on nutritional status, health status, clean water crisis is a very real influence on women, children, the elderly and the disabled. The process of disaster risk reduction is limited by not having time devoted to elaborating the perceived impact of different gender groups. Through the stages of local planning and budgeting process with disaster risk reduction perspective and gender responsiveness, the impact of disasters may not increase the existing gender inequalities. The questions that need answering are:

(1) How the local planning and budgeting process are arranged based on disaster risk reduction perspective and gender mainstreaming approach, especially in the study area, viz., Bantul regency

(2) How the local planning and budgeting process is arranged based on gender mainstreaming approach from the planning phase, validation phase, and accountability phase in Bantul regency, DIY province

(3) How the local planning and budgeting process, is arranged based on benefit analysis especially for women and the gender minority, whether it is an increase or a decrease or no effect for gender equity, vulnerability towards disasters, disaster impact analysis etc based on target MDG's.

A preliminary assessment on the potential risk of malnutrition in a selected tribal community of Periyar Tiger Reserve, Kerala

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KEYWORDS

Malnutrition
disasters
tribal community
Kerala
rural development
ICDS

ABSTRACT

Malnutrition, illness and extreme poverty are recurrently becoming the major reasons for the child mortality with an estimate of 3.5 to 5 million annual deaths across the world. The highly alarming situation rises beyond the death toll of natural disasters. Hence malnutrition need to be considered as a silent disaster spreading across communities and war foot based strategies and policies are required along with strong political will to implement the solutions. Malnutrition in India continues to be at high level in many of the states. In response to combat malnutrition related eventualities, central government in India and its state governments have begun to focus on this issue through various plans and schemes. The primary objective is tending to be the improvements in the health status of the suffering people, particularly women and children. Integrated Child Development Service, Mid-Day meal Scheme, National Rural Health mission etc. are some of the important central government schemes to improve the nutritional and health status of vulnerable population in the rural and urban areas. Though the hunger and malnutrition in Kerala is not as severe as in various other states in India, cases of malnutrition are reported from remote pockets of hilly terrains and coastal belts of Kerala where the tribal communities are inhabited and where the governmental system usually had failed to reach. An investigation has been made in search of malnourished communities in the tribal habitats of Idukki and Pathanamthitta districts of Kerala. The paper discusses in details the present status of the tribal community along with their traditional and historical cultural uniqueness. The preliminary assessment shows that the identified tribal group is severely malnourished in several ways and the people especially children below five years in age are suffering in an acute way. Immediate relief and sustained living packages are indeed very crucial for the specified community.

Flood frequency analysis of Rohini river in east Uttar Pradesh

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KEYWORDS

ARNO model
flood frequencies
Rohini river
hydrological models
climate change
statistical downscaling

ABSTRACT

Floods are most common of natural disasters that cause a lot of damage to life and property of human society. A reliable estimation of magnitude and frequency of occurrence of such extreme events is of great significance in minimizing damages by facilitating proper planning and design of civil engineering structures such as bridges, barrages and dams. In the present study, the L-moments have been used for flood frequency modelling of Rohini River Rohini, which is an important river of East Uttar Pradesh has been selected for this study. This river basin originating from Chure Hills in Nepal flow down to India and joins rive Rapti in Gorakhpur is dependent on rainfall and responds rapidly to rainfall events due to which recurring and destructing floods are quite common every year in the main river as well as in tributaries. Though there are a number of flood control measures implemented in the catchment, the river overflows every season, creating damages and loss to lives and property. Detailed topographic and physiographic information together with hydro-meteorological data are very much essential to achieve effective disaster risk reduction and to enable preparedness for minimising the flood risk. Due to fewer hydro-meteorological data availability and sparse network of rainfall and streamflow stations assessment of runoff and flood volumes are possible only with hydrological models. In this paper we describe a new approach of flood frequency analysis of model-simulated flows which is based on rainfall-runoff modelling using historical rainfall data of the basin and the ARNO model to simulate the flow volumes. In order to achieve the task, initially the ARNO model was calibrated using the available data for the period 1976–2006. The results showed a good agreement between observed and predicted flows (coefficient of determination 0.85, RMSE-83.89 and MAE 54.79). Further, the calibrated model was used to simulate the flows for a period of 2007–2009 with projected rainfall and evaporation from climate change scenario A2 and B1 for region (climate change CGCM3 model, the projected data of rainfall and temperature were obtained International, New Delhi). The simulated annual peak runoff values were then subjected to estimate flood frequencies for various return periods using the L-moments method. Though the model has limitation to calibration in ungauged catchments, when long term records of rainfall and runoff are available, model can be calibrated and used for both simulation and real time flood forecasting. Estimated flood quantities for various return periods from 2–200 years varied from 420–1882 during historic period and between 1019–2313 cumecs for the projected period which shows that there are possibilities for flood volumes to increase in the coming years due to induced climate change. The result presented here gives an idea about the possible flood quantities under the prevailing conditions of the river, such as embankment and river training. The different return period values may of use in planning the flood mitigation activities. The methods used in this study are simple and can be used when limited data are available.

Application of Artificial Intelligence (AI) in disaster mitigation and management

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KEYWORDS

artificial intelligence
DMM
ANN
LSSVM

ABSTRACT

Throughout our history, humans have had to deal with different type of disasters (earthquake, landslide, flood, tsunami, cyclone, etc). Disasters have exacted a high toll in terms of lives and property. Because of their scale and magnitude, governments attempt to manage the impact of these disasters or at least mitigate their disastrous consequences. Disaster mitigation is the process of designing and implementing procedures for reducing the risk associated with the occurrence of a disaster, typically by reducing either the likelihood or the impact of a potential disaster event (Ridge and United States Dept. of Homeland Security, 2004). Disaster Mitigation and Managements such as condition assessment, performance prediction, needs analysis, prioritization, and warning system are often based on data that is uncertain, ambiguous, and incomplete and incorporate judgment and expert opinion. Artificial Intelligence (AI) techniques are particularly appropriate to support these types of decisions because these techniques are very efficient at handling imprecise, uncertain, ambiguous, incomplete, and subjective data. The most used AI constituents, Artificial Neural Network (ANN), Fuzzy system (FS), Genetic Algorithm (GA), Support Vector Machine (SVM), Relevance Vector Machine (RVM), Least Square Support Vector Machine (LSSVM), and Genetic Programming (GP). There are several disaster mitigation and management characteristics that make the use AI approach particularly attractive. These characteristics are: (1) available information may be imprecise, uncertain, ambiguous, subjective (expert opinion), and incomplete, (2) disaster management decisions, such as needs analysis, often involve sophisticated inference rules and require a great deal of expert knowledge. Because of these reasons, the disaster mitigation and management field has been a fertile ground for the application of AI techniques as demonstrated by the many applications that have been reported in the literature.

Epidemiology of stampedes: the case of Sabarimala pilgrimage in Kerala, India

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KEYWORDS

Stampede
Sabarimala
crowd behaviour
pilgrimage

ABSTRACT

Kerala is host to two among the world's largest religious congregations. Amongst the two, the congregation of women on the festival day of Pongala is recognized as the largest gathering of women at a single locality in the world (approximately 2 million every year). The second location, Sabarimala, witnesses a very large annual pilgrimage with an estimated 45–50 million devotees visiting every year. The former has been free of disasters so far in its history, but the latter has been marred by two stampede incidents, one in January 1999 (53 deaths) and the other on 14 January 2011 (104 deaths). The Sabarimala temple is located about 1500 metres above mean sea level within the dense tropical forests of the Western Ghats mountain ranges within the protected Periyar Tiger Reserve and is opened up to pilgrims for a few days in a year. Burkle and Hsu (2010) has pointed out that often there is very little research on the epidemiology of stampede events and the demographic characteristics of the stampede victims. No women died in these stampedes (being a male-only pilgrim site). The unique features of the temple and the rituals associated with it has to a certain extend contributed to the tragedy. The temple is open for worship only for about a month every year, between December and January. Though this temple has been popular with devotees since the late 19th century, it was after 1998 that the number of pilgrims increased. Even though it is located in Kerala, more than 70% of the pilgrims come from the other states of India like Tamil Nadu, Karnataka and Andhra Pradesh. People from Kerala generally make short and quick visits to the temple, unlike others who make it a grant finale to a year of work and worship. The underlying sociological and demographic implications need examination. Amongst the 104 deaths in this stampede only five were from Kerala, 99 being from other states. Thus through a study of the stampede it is not just crowd behaviour that can possibly be modelled but also varying behaviour of populations to matters of belief, penance and maybe altered perceptions of the threats and risks involved. The avarice of local transporters and caterers in scalping the out-of-state pilgrims of their money was at the root of the stampede. Money, faith, nonchalance, and apathy, corrupt practices, and inability to discern risks all added up, in the events that culminated in the stampede. Most deaths were by the lungs and liver getting ruptured by broken ribs, with pressure exerted mostly not due to front to back thrust, but by people trampling over fallen bodies. The stampede was on hill slope some distance from the temple, where some 100,000 pilgrims had gathered on the hill top for a view of a so-called celestial lighting phenomenon that culminates the season of pilgrimage, and the temple shuts its doors till the next season. Naturally, being a forest, but with savanna type vegetation of grasses, there was just a small trekking path of about 3 m width. The stampede lasted less than eight minutes, from 20:25, on this path. No crowd control measures were in place. One possible solution to the crowd situation is to open the temple up for longer periods, and spread over a year, but these changes have cultural and religious implications. With increasing pilgrim populations, urbanization of the forests will be accelerated. Crowd control through restricted trekking paths, predetermined appointments for temple visit, base station with facilities for pilgrims to rest before they begin their trek based on their predetermined time slot of visit, and more participation of police and other administartive forces from the the neighbouring states who can speak the language of the majority of the pilgrims maybe some remedial measures. An integrated study across disciplines is essentail to bring out the crowd dynamics of this complex pilgrim spot, and such a study would also bring to light the interactions between religion, belief, politics, money, power, gender and language.

Disaster risk reduction and climate change

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KEYWORDS

climate change
adaptation
DRR

ABSTRACT

Anomalous precipitation, extreme weather evens and dry weather are being caused by anthropogenic climate change, as reported. IPCC has included so in its most recent report. Heat waves in Europe, increasing intensity and frequency of hurricanes, in the Atlantic, Pacific and Indian ocean regions, droughts in Africa, and southern parts and flooding as weather-related disasters, due to climate change impacts. These are affecting human population and livelihoods destroying property, lives and crops in many parts of the world particularly in vulnerable areas. Natural hazards from climate related changes are increasingly affecting developing parts of the world causing an adverse import on the process of development. The World Conference on Disaster Reduction calls for international cooperation to tackle this issue, since both developed and developing countries are a rick from hazards turning into disasters.

The profiles of natural hazards and disaster are changing due to changes in climate, altering the underlying environmental health and demographic risks while introducing new threats. There is a need and opportunity to reduce current and future vulnerabilities by building an and expanding disaster risk management efforts, in addition to and as part of climate change mitigation and adaptation protocols and plans.

Coastal hazards: Are we doing enough?

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KEYWORDS

coastal hazards
sea-level rise
preparedness

ABSTRACT

All across the world, the coastal land is home to mega population centers and scores of smaller cities and towns, which are wide open to and practically defenseless against the most destructive forces of nature like, severe-storm-related hazards, hydrologic floods, beach erosion and tsunamis. Added to this, several coastal communities face massive threats to livability and property primarily contributed by anthropogenic actions, like green house warming induced sea level rise, land subsidence due to mining or withdrawal of fluids from subsurface, pollution of coastal waters, oil spills and sea water ingress into coastal aquifers. That eleven of the fifteen largest cities of the world are located near the coasts of seas or estuaries is an indicator of the vulnerabilities. ăIn India, state capitals of some littoral states (for e.g., Mumbai of Maharashtra, Panaji of Goa, Trivandrum of Kerala, Chennai of Tamil Nadu and Bhubaneswar of Orissa) are in the coastal land. Conterminous India, with its pretty long shoreline of 5700 km, (Kerala sharing roughly 10%) and being closer to the equator, has its own share of worries arising out of natural hazards. Vulnerability of the population in the coastal land to hazards is directly linked to the morphology of the coastal land (elevation), population density and proximity of population pockets to the shoreline (proximity), or in other words to placing property and lives ăinappropriate areas. Human populations, cities, ports, and wetlands in low-lying coastal areas, will be affected by inundation, erosion and salination as a result of a climate change induced sea level rise between 0.3 and 0.9 m say by the end of this century, due to rising greenhouse gas emissions. ăA chief consequence of SLR is coastal erosion and loss of land and contamination of coastal fresh water aquifers. Consequences of a global sea level rise would be spatially non-uniform because of local or regional vertical crustal 'movements', differential resistance of shoreline to erosion, varying wave climates, and changing long shore currents. Intensive development and investment in the coastal land make them vulnerable at the time of erosion, hydrologic storms, storm surges or tsunamis. Vulnerabilities due to Coastal hazards are preventable either by structural interventions or simply by staying away or relocating in the backshore of zones potential threats. While the structures reflect the wave energy, the natural vegetation helps to absorb the same. Options are two sided, like, do nothing and get out of the area or adapt and accommodate. One of the management responses is retreat from the affected area and move toward the backshore. Secondly by building elevated houses on stilts, the affected communities could be saved. Third option is basically preparedness like education and creating awareness and placing early detection, warning and communication and emergency evacuation systems. Preparedness on the part of local and state or national governments in warding off the damages of hazards is fundamental to it. The recently launched program by the MoEF, GoI for mapping the vulnerable coastal areas of the Indian littoral states and creation of an institute in Chennai for research on coastal hazards are right initiatives. But the states contribution in this regard is not yet crystallized fully.

Drought vulnerability assessment and mapping: Approaches and methods using geospatial tools

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KEYWORDS

drought
risk
vulnerability
SPI
VCI
GIS
multi-criteria analysis
HDI
yield

ABSTRACT

Paradigm shift in drought management world over from response and relief centric towards preparedness, prevention and mitigation centric has increased attention and urgency to undertake research on assessment and mapping of vulnerability. The study reported here demonstrated a methodology to assess and map agricultural drought vulnerability during main kharif crop season and compare its intra-seasonal variations in the Rajasthan state of India. A conceptual model of vulnerability based on variables of exposure, sensitivity and adaptive capacity was adopted and spatial datasets of key factors contributing to vulnerability were generated using remote sensing and GIS. Hazard exposure was based on frequency and intensity of gridded Standardised Precipitation Index (SPI). Agricultural sensitivity was based on soil water holding capacity as well as frequency and intensity of NDVI derived Trend Adjusted Vegetation Condition Index (VCI_{Tadj}). Percent irrigated area was used as a measure of adaptive capacity. Composite agricultural drought vulnerability was derived separately for early, mid, late and whole kharif seasons by composting rating of factors using linear weighting scheme and pairwise comparison of Multi-Criteria-Evaluation. The regions showing very low to extreme rating of hazard exposure, drought sensitivity and agricultural vulnerability were identified at all four time scales and their statistics calculated. The results indicate that high to extreme vulnerability occurs in more that 50 percent of net sown area in the state and such areas mostly occur in western, central and southern parts. The higher vulnerability is on account of non-irrigated croplands, moderate to low water holding capacity of sandy soils, resulting in higher sensitivity and located in regions with high probability of rainfall deficiency. The mid and late season vulnerability has been found to be much higher than during early and whole season. Significant negative correlation of agricultural vulnerability rating with crop productivity and socio-economic indicator of Human Development Index (HDI) proves the general soundness of methodology demonstrated in this study. The study on drought vulnerability mapping is expected to lead to better preparedness and mitigation oriented management in Rajasthan State.

An emergency essential service module for natural disasters

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KEYWORDS

natural hazard
disaster
climate change
emergency essential service module
cyclone
coastal areas
local material and technology

ABSTRACT

Bangladesh is most vulnerable to several natural disasters and every year natural calamities upset people's lives in some part of the country. The major disasters concerned here are the occurrences of flood, cyclone and storm surge, flash flood, drought, tornado, riverbank erosion, and landslide. The geographical setting of Bangladesh makes the country vulnerable to natural disasters. The mountains and hills bordering almost three-fourths of the country, along with the funnel shaped Bay of Bengal in the south, have made the country a meeting place of life-giving monsoon rains, but also make it subjected to the catastrophic ravages of natural disasters. Its physiographic and river morphology also contribute to recurring disasters. Abnormal rainfall and earthquakes in the adjacent Himalayan range add to the disaster situation. Effects of *El-Nino-Southern* Oscillation (ENSO) and the apprehended climatic change have a great impact on the overall future disaster scenarios. Most of the coastal areas of the world are at risk from natural hazards resulting from geological and meteorological disturbances. In Bangladesh, coastal areas are ecologically sensitive and climatically vulnerable because of the continuous process of erosion and accretion, which needs to be protected for natural vegetative growth and a forestation. It also contains one of the largest (5000 sq. km) mangrove forests in the world. The area covers over 6.8 million of households in 147 *Upazila* (Sub-district) along the coastal belt, which considered as risk prone. This Research project deals with one such measure that is in need of attention — that can directly help environmental refugees as an instantaneous response addressing their need for help. An Emergency essential Service module is proposed to cope with the immediate aftermaths of natural disasters when vast multitude of population is faced with homelessness having neither food, nor a roof over their heads. The module will offer shelter to distribute emergency services that are essential for theses environmental refugees for survival, viz. facilities like first aid, medical unit, unit for dry food/goods storage, relief distribution areas, etc. Of necessity such a module should be built with local material and technology — buildable in a very short time with minimum cost. Conceptually the module should be an immediate solution that can be built overnight when needed and dismantled and stowed away when the need disappears — to be available for reuse once again when disaster strikes again. The paper will focus a specific case study cyclone prone site where the research project will design a module with above mentioned services and techniques.

Landslide susceptibility mapping of the Munnar region, Southern India using remote sensing and GRASS GIS

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KEYWORDS

GIS
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ABSTRACT

Landslides are one of the natural hazards that affect at least 15% of land area of India exceeding 0.49 million sq km. Landslides have had disastrous consequences and in 2005, over 500 lives were lost in India due to landslides. Landslides are common in the Himalayas and in the Southern India, especially in the Nilgiris and Kodaikanal hill ranges. The aim of this study is to analyze the factors controlling the landslides in the Munnar region of southern India and prepare a landslide susceptibility map using Remote Sensing and GRASS (Geographic Resources Analysis Support System) GIS as the tools. The study area, known for its tea plantations tourism, has been experiencing landslides recently. Rainfall, geology, morphology, physical and human factors can be considered as triggering factors. The other causes which include slope, landuse, vegetation density, availability of unconsolidated sliding material etc. have to be mapped and studied in detail to arrive at an accurate landslide hazard zonation map of this area. This paper aims to study the satellite images, rainfall data and other collateral data of Munnar region and decipher the causative factors that are active in the region for the occurrence of landslides. Proper rank and weights for factors influencing landslides were assigned for the themes. Overlay analysis using GRASS GIS software resulted in a map showing the severity of landslide in as high, medium and low in the study area. Thus, it is seen that remote sensing and GRASS GIS are well suited for identifying landslide prone areas.

Disasters: A sociological perspective

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KEYWORDS

suicide
disaster
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social dimension

ABSTRACT

The paper is comprised of *four* sections and the following are highlighted in the paper: The *first* section, consisting of Introduction, Historical background of the term disaster, and social dimensions of disasters. In this section of the paper, how disasters are defined, conceptualized, perceived sociologically will be discussed. This will be followed by the explanation of disasters and its impacts from sociological point of view. In a more theoretical way the social dimensions of disasters from sociological standpoint will also be discussed. This paper stresses the significant contributions to the conceptual typology of sociological disaster research. The *second* section addresses the Perspective: the argument is developed in such a way that it will enable us to understand, analyse and interpret the causes and consequences of disasters from sociological point of view. Besides, few studies of hazards and disasters have been reviewed from a sociological perspective. In this section of the paper an attempt has been made to explore what research has been done to address disasters and to what extent disasters are highlighted and analysed from the sociological perspective. The *third* section discusses Durkheim's sociological interpretations of Suicide including a brief discussion of social dimensions of suicide, the four types of suicide, methodological aspects of the sociological study of suicide, and to discuss suicide from social aspects. Also it is attempted to stress the significance of the study of suicide as a subject; and the need of up-to-date statistics of suicide; and what strategies to adopt for the early intervention and prevention of suicide. In the course of discussion, the paper seeks to explore the increasing and changing factors leading to suicides among youths in the contemporary situations. The *fourth* and last section ends with concluding remarks. In this paper it is stressed that social dimensions of disasters or, to be more precise, sociological approaches to disaster research must be given serious consideration. By drawing upon social theory and empirical research, policy makers can enrich their understanding of disaster risk, and therefore, also develop more effective and equitable mitigation and response strategies (in reducing immediate and future risks in the context of disasters) in future.

Critical reflections on Post disaster recovery and reconstruction in Andaman & Nicobar Islands, India

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KEYWORDS

disaster
A&N administration
island and vulnerable groups

ABSTRACT

The article examines the post-disaster recovery and reconstruction activities to the major and minor disasters which are frequently disturbing the life of the islanders. The paper is focusing on the various actions taken by the A&N Administration as well as the social and developmental organizations, extracting lessons learned and identifying specific implications towards the episode. The sudden occurrence of the frequent earthquake distracts the normal life of the islanders and it hit in almost all part of the areas of the Andaman including North, Middle and Southern parts. The paper is at first attempt to review the recovery and reconstruction activities of the various stakeholders in relation with the December 2004 tsunami and earthquakes. Later the author point out the frequent incidence of the various disasters especially earthquake, flood and climate related disasters. Lessons that have been learned from the post-disaster response are summarized, including: (a) lessons that apply primarily to the relief phase; (b) lessons for rehabilitation and reconstruction; (c) do's and don'ts; (d) island specific observations. (e) finally the impact and the long term implications of the intervention on the livelihood of the islanders in the post disaster response period. The author describes his experience and tries to analyze the role of administration and the various other stakeholders in the areas of disaster recovery and reconstruction. The author finally suggested the unavoidable elements needs to be incorporated in the post disaster response phase.

Community-based adaptation to coastal hazards: A scoping study among traditional fishing communities in Kerala, India

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KEYWORDS
coastal hazards
adaptation
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fisheries

ABSTRACT

Traditional fishing communities in India are vulnerable to different types of coastal hazards and related livelihood uncertainties. Moreover, with challenges such as global warming and climate change, these coastal communities have become more susceptible to the vagaries of nature. Taking the case of coastal fishing communities in the southern districts of Kerala, India, this paper explores the adaptation strategies that emerge in the context of environmental changes and coastal hazards. Firstly, this paper examines the nature and impact of coastal hazards on sustainable livelihoods. Secondly, it analyses the nature and consequences of adaptation strategies followed by different stakeholders in coastal resource management with respect to environmental degradation and coastal hazards. The findings of this study show that stakeholders such as state authorities mostly resort to technological adaptation such as the construction of seawalls, breakwaters, and groins. However, these costly interventions seldom take into consideration the livelihood dependencies of traditional fisherfolk on their coastal resources. This paper also shows that such interventions enhance the vulnerability of coastal communities to natural hazards. Territorialisation of fisheries, resource use conflicts, and migration are other visible outcomes of such interventions. This study is qualitative in nature. Data was collected using in-depth interviews. Data was collected from traditional fisherfolk, elected representatives of local governing bodies, and officials from the state departments. The findings of this paper will significantly contribute to existing debates on community-based disaster risk reduction and adaptation strategies.

A study on the role of self help groups in communicating risk and risk management strategies for community resilience and security in Tamilnadu

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KEYWORDS
natural disasters
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ABSTRACT

Natural Disasters like Cyclone, Flood and Tsunami have been affecting the coastal communities for a long time. The prime reason behind this impact is the lack of last mile communications. In a disaster situation, timely warnings allow people to take actions that save lives, reduce damage to property and minimize human suffering. To facilitate an effective warning system, there is a major need for better coordination among the early warning providers as well as those handling logistics and raising awareness about disaster preparedness, security and management. There are many new communication technologies that allow warning providers not only to reach the people at risk but also to personalize their warning message to a particular situation. Opportunities are available right now to significantly reduce loss of life and properties if disaster warning systems can be improved. In this study, the researcher analyzes how different communication strategies play an important role in disseminating information among the people during emergencies using survey and interviews. This paper also looks into the effective role of self help group women in communicating risk management strategies to coastal community in the Tamil Nadu state of India.

Land use planning: Technique to reduce vulnerability to flood in coastal village — A case study of Kaikhali village in South 24 Parganas, West Bengal, India

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KEYWORDS

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ABSTRACT

Socio-economic vulnerability to disaster is not in isolation with physical vulnerability. Socio-economic conditions largely depend upon how activities are spread over the land i.e. land use. In an urban setting it is largely based on anthropogenic decisions and choices but in a rural setting it is more of the natural characteristics viz. soil, topography, geomorphology, vegetation cover that decides the use of the land viz. agriculture, fishery, plantation, forestry, fishing etc. Hence, to reduce socio economic losses due to flood, it is essential to plan physical distribution of activities concordant to the natural ecosystem (coastal in this study) of an area so as to sustain livelihood even after a natural disaster viz. flood. This paper will focus on land use/land cover conversion, functionally & topographically suitable location for flood shelter and improved transportation network to enhance the economy. This study had been completed using Geographic Information System (GIS) and Remote Sensing (RS) techniques.