

# **COMMUNITY BASED DISASTER INFORMATION MANAGEMENT SYSTEM: PERSPECTIVE BANGLADESH.**

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## **ABSTRACT**

The most efficient and effective disaster preparedness systems and capabilities for post-disaster response are usually provided through volunteer contributions and local authority actions at the neighborhood level. Specific actions are also needed at the appropriate level of local government, in collaboration with NGOs and private sector enterprises working in close coordination with community participants, for disaster preparedness and capacity development with rapid implementation plan.

Active participation of local communities is essential for successful disaster reduction policy and practice. Vulnerable communities in developing countries have experience and resources to prevent losses from disaster. Communities are rich in experiences of coping with natural disasters both in preparedness and emergencies. Being knowledgeable about their own environments, often they would be able to predict on untoward incidents.

Community based disaster preparedness and mitigation activities are found to be the most effective ways of reducing disaster vulnerability. The first line of disaster response is at the local level, where simple planning and preparedness measures can substantially reduce the impacts of natural hazards.

With the vast territory, huge population and similar geoclimatic conditions, Indian sub-continent is exposed to common natural calamities. Located in the same basin, Bangladesh also suffers extensive losses of lives with severe damages to property and crops in repeated disaster occurrences. During the past 21 cyclones in the Bay of Bengal (Bangladesh and India) 1.25 million lives have been lost (BMTPC 2001). Bangladesh has one of the highest vulnerability index to natural disaster.

The major natural disasters that effect Bangladesh are cyclones, floods, riverbank erosion, tornedoes, droughts and earthquakes. The CERD Disaster Database lists 93 disasters over the period 1986 to 1995. Of these, 40 were cyclones and 31 floods. The cyclone disasters in 1970 (300,000 dead) and 1991 (138,000 dead) are among the worst natural disasters in the world (CRED, 2002).

At the national level, several government ministries and agencies are playing increasingly crucial role in the overall disaster management system. Over the years NGOs have flourished and virtually grown into a mass movement. A wide range of community-based disaster preparedness activities are being implemented mostly by NGOs.

With the advent of information and communication technologies, there has been increased demand of ICT based disaster management system at the national, regional and local platforms. National level forecasting for cyclones and floods are managed by the Bangladesh Meteorological Department and Bangladesh Water Development Board. Interactivity among these organizations and dissemination of information to the local level at the earliest possible period with minimum time delay would strengthen the disaster preparedness programmes. This would also put impact on livelihood of rural communities by mitigating losses during natural disasters.

Incorporating electronic communication media and existing information backbone a disaster management communication network can be formed in collaboration with agents involved in disaster preparedness at remote locations. Utilizing regional set up of the Sustainable Development Networking Programme (SDNP) of Bangladesh, a database resource can be superimposed on the geographically distributed database servers. A web site containing data and information on disaster plans can assist in mitigating damages in the event of disaster. Information on recovery techniques can be accumulated in the database with link to other available resources.

## INTRODUCTION

A major portion of South Asia is extremely vulnerable to both seismic and hydro-meteorological hazards such as floods, typhoons, droughts, and derivative disasters such as forest fires and landslides. This vulnerability is compounded by socio-economic conditions, which exacerbate the impact of disasters. These conditions include:

- 1) population strain- increasing number of people affected, and resulting in more people inhabiting marginal lands;
- 2) environmental degradation- affecting the natural resiliency to disasters; and
- 3) investments in infrastructure in hazard prone areas with increasing vulnerability and potential loss of assets.

In preparing for and implementing post-disaster relief, rehabilitation, reconstruction, and resettlement, governments at the appropriate levels, including local authorities, in partnership with all interested parties, should establish reliable communications, and response and decision-making capabilities at the national, local and community levels; and strengthen scientific and engineering capacities for damage assessment and monitoring and for special rehabilitation and reconstruction techniques (Article 178, c and f, Section IV C-11. Disaster prevention, Sustainable human settlements development in an urbanizing world, Habitat Agenda.)

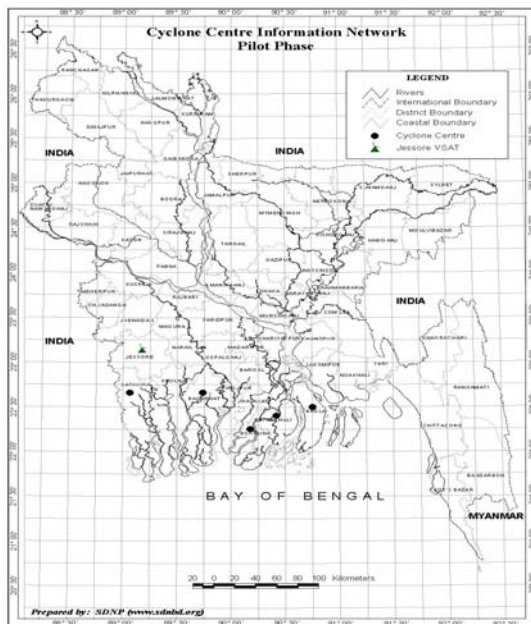
SDNP being a global catalyst of UNDP in Bangladesh acting towards implementing policies and initiatives of Agenda 21 has started its activity from 1998. It is highly logical that SDNP would be taking a leading role in information networking throughout the country by providing electronic connectivity to individuals, corporate organizations, academics, researchers, government and non-government agencies including UN and International bodies in Bangladesh. By incorporating IT methodologies on disaster preparedness the network would easily be converted into mass information dissemination media for community based disaster management system. Location of six regional nodes of SDNP is shown in the following figure:



Electronic communications among the SDNP networks within the country is an explicit example of computer network using minimum bandwidth sharing different localized servers and at the same time offering improved information services to the remotely located end users. Regional servers located at divisional levels are added advantage of this network in reaching out the remote communities participating in community based activities. With minimum upgradation and effort the existing network can be utilized to accommodate electronic based disaster management network.

In order to prevent natural disasters governments at the appropriate levels, including local authorities, should promote and encourage broad-based participation in disaster preparedness activities by giving to the population living in the vicinity of a dangerous activity adequate and regular information on the

potential hazards. To intensify local level activities SDNP would like to establish information centres at cyclone shelters across the coastal belt of Bay of Bengal as shown in the figure below:



## OBJECTIVES

Over the years the disaster management community has been emphasizing on developmental approach to top-down disaster management processes with recognition of significant role of community organizations, local government, state government, national government and above all communities themselves.

Community based relief requires an effective relief agency of the government, one that initiates, facilitates, encourages, monitors, and matches the local community-based efforts. Without an effective [local government] relief agency, effective disaster management, community-based or top-down is impossible. (Mihir Bhatt, Disaster Mitigation Institute, India.)

The SDN supported network can establish a disaster information management system to:

- Outreach programs to develop and implement mechanisms that increase community awareness and improve management of natural hazard risks and vulnerabilities.
- Increase awareness and understanding at the community levels of the sectoral impact of natural hazards
- Demonstrate strong training programs for community leaders, possess communication and coordination mechanisms to facilitate preparedness and response capabilities
- Assist in monitoring, forecasting and early warning organizations and assist in warning dissemination incorporating forecasting through mass information dissemination system for community disaster preparedness
- Enable vulnerable communities and local groups to understand climate forecasts and undertake corresponding disaster preparedness and mitigation activities

- Incorporate innovative approaches and technologies for reducing risk to vulnerable communities, incorporating local context

## **METHODOLOGY**

Networking minimizes the task of un-optimizes searching and sequencing in distributed environment. Individual stations connected to cluster of networks and eventually interconnected together using similar infrastructures and optimized protocols are becoming popular throughout the virtual communities (Rahman, H., 2001).

Disaster mitigation can be divided into three action oriented programmes, namely; preparedness, response and post-disaster development. In this aspect community based initiatives are potentially more resource efficient and better self sustained.

Establishing networking facilities in cyclone shelters and disaster preparedness centres, early warning systems can be strengthened. Response time can be drastically reduced during sudden catastrophes. Utilizing database resources, information databank, knowledge networking the post-disaster development activities can be rapidified with minimum effort and expenses.

A critical element of the USAID/DCHA/OFDA strategic plan is intermediate Result 1.4: “Increased adoption of mitigation measures in countries at greatest risk of natural and human-caused disasters.” For this purpose, mitigation is defined as any sustained action that reduces or eliminates risk to people, livelihoods, and property from natural hazards. Mitigation is accomplished by reducing vulnerability, increasing the capacity of risk management systems, or by modifying, where possible, the hazard (APS, 2002).

Commonwealth Of Learning (COL) of Canada has indicated interest in providing one band FM radio stations in cyclone shelters across the coastal belt of the northern region of the country where SDNP is going to establish virtual information centres to outreach the mission of cross cultural development initiatives within the country. Few other Non Government Organizations (NGO) have also shown interest in forming institutional collaborations within fields of mutual interest. Negotiations are in progress to include some other international organizations under the umbrella of sustainable development in Bangladesh.

Remote cyclone shelter across the coastal belt of the country could be taken under networking umbrella of SDNP through dial up connection. Transformation of these cyclone shelters to virtual information centres is just a matter of time and in a very short period of time they would be given shape of community based learning points. Integrating the networks of SDNP, Bangladesh Open University (BOU) and similar organizations a programme can be initiated by publishing regular electronics journal, organizing email discussion forum and regional development activities incorporating grass-root level development activities.

This information backbone can be utilized further for disseminating agricultural related information, consumer commodity related data, environment and ecological data, programme of distance education, different national awareness raising activities coming from SDNP server, BOU server and other networks linked to these server and networks. During evening time, the FM transmitters could be easily be used as a community based radio station disseminating information covering mentioned activities as obtained throughout the day from the network. Towards disaster management approaches the network can support efforts to spread best practices in disaster preparedness and mitigation techniques throughout the region, especially among the three disaster prone South Asian countries; Bangladesh, India and Nepal.

Divisionwise hazard maps, national level earthquake hazard maps, wind and cyclone hazard maps; and flood hazard maps, etc. can be created with specialists in this field and put into the servers for study, research, action and dissemination purposes. Risk Tables containing “distribution of houses by predominant materials of roof and wall with level of damage risk” can be build and updated regularly by

collecting data from field level data accumulators. The table can contain data on earthquake intensity, wind velocity and flood.

## **BARRIERS**

In the long run, community efforts lack effectiveness if they are not supported and treated as an important part of any integrated and sustainable disaster mitigation strategy. Thorough and effective monitoring plan should be implemented with modular pattern of close observance. Bottom-top approaches seems applicable in rural communities. Local group will report to group supervisors and in effect they will reach district and central level of monitoring teams.

Coordination among agencies acting in similar approaches delays effective output at the grass root level with increasing possibilities of duplication of efforts and un-optimization of resources.

## **CONCLUSIONS**

During the International Decade for Natural Disaster Reduction 1990-2000, Yokohama meet declared a few important messages, Disaster Prevention, Mitigation and Preparedness are better than disaster response; disaster response alone yields temporary relief at a very high cost; and prevention contributes to lasting improvement in safety.

The following steps need to be taken for an effective disaster management system:

- Identification of vulnerable locations;
- Preparedness; and
- Formulation of strategic implementation plan.

To achieve success in these aspects, creation of awareness for disaster reduction should be given prime importance among policy initiators, decision makers and administrators at national and local levels, professional bodies, financial institutions, NGOs and voluntary organizations.

With its vast territory, large population and unique geoclimatic conditions, Indian sub-continent is exposed to natural catastrophes traditionally. Even today the natural hazards like floods, cyclones, droughts and earthquakes are not rare or unusual phenomena in the country. While the vulnerability varies from region to region, a large part of the country is exposed to such natural hazards which often turn into disasters causing significant disruption of socio-economic life of communities leading to loss of life and property (BMTPC, 2001.)

Following these consequences, a number of countries have adopted decentralized state structures and functions, accompanied with re-organizing government and civil bodies. In Bangladesh, Red Crescent Society and quality of NGOs have put forward a dependable platform in remote regions for disaster preparedness and management. The scope of disaster management activities need to expand implying participation of wider range of stakeholders in much wider range of activities. Local government institutions need to build up their capacities in order to meet the growing demands in the area of disaster management.

Capacity building at local and regional levels is needed for undertaking rapid-assessment surveys and investigations of the extent of damages in post-disaster periods.

Detailed databases need to be created on hazard occurrences containing damages caused to buildings and infrastructures and the economic losses suffered and its accessibility should be ensured regarding preparedness, and research data for effective pre and post disaster analysis with data on mitigation techniques and action plans.

National level institutional mechanism should be enhanced to assist and advise in formulating short and long term disaster preparedness, mitigation and prevention techniques.

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# **FACILITATING COMMUNITY INITIATIVES: UELCI EXPERIENCES ON DISASTER MITIGATION IN INDIA**

**Dhirendra Panda, United Evangelical Church in India**

*The United Evangelical Church in India (UELCI), a federation of 10 organizations, has been devoted to social developmental activities since 1970s. Its members belonging to these Churches are mostly Dalits, Adivasis, fisher-folk and backward communities, predominantly, settled in climatic Eco-zones in the coast, forest and arid areas, which are affected by perpetual droughts, reoccurrence of cyclones, flash floods and heavy rains. Among them many Church and Non-Church related Non-Governmental organisations are also working for the welfare of these communities.*

The role UELCI in large-scale emergencies became pertinent after the Super Cyclone in Orissa in the year 1999, when more than 10,000 people lost their lives and 2 lakhs families became homeless. The Government of Orissa invited UELCI and its partners, who could effectively work in the crisis phase and in the short term rehabilitation of the victims as repair of houses and providing livelihood assistance etc. UELCI worked through the partners of a well-known and field based network called Orissa Development Action Forum (ODAF) in the Super Cyclone affected areas.

Almost after 25 years of development and emergency assistance, UELCI has built up relationship with many local NGOs in India through its programmes. In Orissa it has been successful in building alliance to engage in advocacy and lobby work against the policies and acts that were anti-people, anti-environment and anti-development. The issues related Adivasis, Dalits and Fisher folk were part of UELCI agenda. Displacement, Mega development projects that destroy local environment, commercial plantation, Land Acquisition ACT, V Schedule, Panchayati Raj, Conflict over control of natural resources by the corporate-houses were some of the areas, where UELCI continues to collaborate and cooperate with network of NGOs and People's Movements.

## Its recent involvements in Rehabilitation of Victims

Orissa Super Cyclone in 1999 -2000  
Orissa Statewide Flood in 2001-2002  
Andhra Pradesh Cyclone in 2001-2002  
Gujarat Earthquake in 2001-2002  
Gujarat Communal Riots in 2002

## **Guiding Principles**

Considering the recurrence of Disasters in India, it has been working for Sustainable Disaster Management keeping the community development approaches at the core: which is a detachment from traditional "relief- delivery" approach. While the traditional approach relates to moving into work after disaster and moving out before proper rehabilitation emphasizing immediate relief service without caring for the empowerment of community members, UELCI considers peoples empowerment as corner stone for Community based Disaster Preparedness.

UELCI does not offer such models that does not fit with the taste, tune and texture of people within the given socio-economic realities

## **Rights based approach**

*Disaster victims have the right to be rehabilitated*

*It strongly believes that it is the responsibility of the state to take all necessary measures, short-term or long-term, to protect its citizens from the fury of disasters.*

It struggles to influence public policy in favour of people through various democratic ways and means.

### **People Centered Disaster Preparedness/Management**

*Community members or victims are at the center of planning, decision making and execution of disaster management.*

It networks among the victims, so that they can combine their efforts to prepare against Disasters.

Instead of creating centralised resource pool, it believes in developing local skills and knowledge.(Capacity Building Programmes)

Democratic Decision Making Process

*Irrespective of religious belief, caste, colour, creed or gender bias each individual has equal right to participate in decision- making process.*

### **Transparency**

All the stakeholders are informed of the intentions or contentions of activities.

Community Development as the axis of Relief and Rehabilitation

UELCI work does not complete just with the completion of relief / rehabilitation work. Rather it facilitates community empowerment and development.

### **Community Empowerment**

*Empowerment of community is the key to community based disaster management and its sustainability.*

### **LESSONS LEARNED**

Through long-standing observations UELCI has been able to learn following things-

- Like some other Asian Countries, Nature has cursed India with disasters that cause widespread damage and devastation in India with a high frequency. Floods, Droughts, Cyclones, Earthquakes, Landslides and avalanches are some of the major natural Disasters that repeatedly and increasingly affecting India.
- However, the list of Disasters does not exhaust with these natural ones. There are man made tragedies like toxic-gas leak from Union Carbide industry in Bhopal, communal riots(Hindu vs. Muslim) in Gujarat killing more than 2500 innocent people and damaging thousands of houses etc.
- The disasters, every year, compel the developmental Agencies to put more time, energy and money for it diverting their main agenda.
- Frequency of Disasters as Cyclone, Drought, Flood is now increasing year by year
- For example, the heat-wave in 1998 in Coastal Orissa (India) took away 1500 lives, in 1999 two major cyclones in Orissa (one Super Cyclone with a wind-speed of about 350 km/hour) affected 15 million people, and killed about 25000 people, in 2000 a severe drought affected 29 districts, in 2001 an unprecedented Floods affected 24 districts out of 30. This current year people are facing another severe most drought.
- In all those disasters extreme-behaviour of the climate is being marked. In 1998 Coastal Orissa had reached a temperature about 50<sup>0</sup> C which was a record while normal temperature in Bhubaneswar remains around 40<sup>0</sup> C during the same season, which was unthinkable 20 years back. The flood in 2001 was unprecedented due to its intensity and extensiveness.

- This year Drought is considered a rare phenomenon not seen in the whole of last century. The shortage of rainfall has broken 40 years record. This year less than 60% rainfall has been recorded all over India. Over 320 districts have been identified as Drought prone.
- It seems frequent changes in climate due to Global warming caused basically by human activities will not only make Disasters inevitable but also affect agriculture, health, livelihood with negative impacts. It is known to everybody that the industrialized and Developed countries are more responsible in this regard than the developing countries .

### **Globalization -Trade liberalisation increases Vulnerability**

Trade liberalisation or Globalisation induced economic reforms has been creating more impoverishment by largely reducing existing job opportunities, pushing further down the small, middle and marginal farmers and wage labourers who are of the lower economic strata; slicing down social welfare schemes creating hindrance for the development of local infrastructure and preparedness. These lead to increasing vulnerability in the face of disasters of the common people in urban and rural India.

### **Riots and Wars**

Increasing conflicts in between religions, communities, tribal vs non-tribals, dalits vs higher castes are giving birth to disaster ie. Gujurat carnage.

We must not forget the disasters being faced by Afghanistan and other war-torn countries.

Considering above facts Disaster has become a regular part of Human life today. Development can not be thought of without addressing the effects of Disaster. Now any Development thinker or worker cannot but integrate Disaster Management with Developmental option. This is UELCI's foremost learning. Thus it will be its endeavor to slowly establish and anchor this approach in critical Disaster prone zone as a model and experiment within not only Church related institutions, but also or Non-Government

Organization as well as through them building intervention for long term intervention.

### **Operational Strategy / Approaches adopted by UELCI**

*Application of various strategies/approaches UELCI found followings are proved to be successful:-*

#### ***Links Disaster Mitigation efforts with political, Human Rights issues activists and organisations***

- Involves a local experienced NGOs (having knowledge of the region, being culturally sensitive, active in the region and more pro-poor, capable to take up fight for justice) / CBOs / POs in Disaster Operations, besides involving community groups.
- Facilitates the formation of village-level development committees, the basic unit to spearhead Disaster Mitigation operations.
- Organise the Community members to demand fulfillment of their rights from the Government.
- Facilitates for the creation of local infrastructures by the community itself.

#### ***Beneficiary Selection:***

- Disadvantaged section of the community as *Dalits* (untouchables), indigenous tribes, fisher-folks, women, children, disables etc.
- Economically marginalised people as agricultural land labourers, share croppers, marginal farmers, small farmers and people under below poverty line.
- Villages, non- attended or sparsely attended to by the Government or other NGOs.

- Beneficiaries selected on the basis of observation of experts, CBOs, local People's Representatives and is being done by the village level committee

**Gender:**

- Utmost emphasis on women participation for identification and address of women specific needs during relief and rehabilitation works.
- Recruitment of mostly women as village level volunteers.
- Formation of women groups at village/hamlet level

**Housing:**

- Ensure community initiative through opting for replicable housing models and beneficiaries' involvement.
- In flood-prone and cyclone-prone areas Flood-resistant 'frames' (concrete pillars and tin-roofing) are supported by UELCI, required unskilled manual labourers are put by the beneficiaries themselves. Food items are only supported to the persons engaged for this on *per diem* basis. Beneficiaries are mobilised to construct mud walls by themselves. Future Floods may wash away the mud only, which can be reconstructed by the beneficiary himself without depending on outside assistance.
- Advocates for and makes the community to avail of the entitled housing compensations from the State.

**Food Distribution**

***Discourages free Food Distribution, where community initiative may be killed, except unavoidable situations***

- Provides food materials in lieu of labour contribution by the beneficiary for making their own community infrastructure
- Assistance for Agriculture
- Seeds are supported to marginal/ small farmers through village committees under an agreement that the beneficiaries would return the seeds through the village committees after harvesting.
- Seed banks are opened with the seeds collected from villagers to meet future need during Calamities.

**Health and Sanitation**

- With primary concern it helps the community to use safe drinking water
- Medicine kits are supplied to village committees.
- Village volunteers are trained/ oriented to administer medicines, where doctors or qualified staff are not available
- Community medicine banks are created.

**Some practical learning are: -**

- Involvement of community members in the process makes the community establish their ownership over the project, process and outcome.

- Interaction amongst affected people, community leaders, experts, CBOs / Local NGOs and UELCI facilitator during various phases beginning from damage assessment to implementation, impact assessment helps in joining the people's experience and experts' knowledge.
- Targeting indigenous tribes, *dalits* (untouchables), agricultural labourers, marginal/ small farmers and other vulnerable people lying at the bottom-line of the society, ignoring their caste, creed, religious affiliations helps in bringing confidence among these marginalised people. Although it creates casual tensions among the people at upper strata, it makes community to stand against communal frenzy.
- Recruiting women as community volunteers and to work as community spokespersons helps in building confidence and trust among women-folks and to take up women-specific problems in Disaster mitigation activities.
- Activating and involving local political workers in Disaster mitigation activities strengthens Advocacy / lobbying actions to pressurize the Government authorities to provide compensations and other due benefits.
- Low cost housing or local community infrastructures and involvement of communities along with their own contribution inspires other marginalised sections, beyond the targeted areas to replicate the models without feeling hopeless.
- Integrating Disaster management Programmes with community development efforts brings entire community together and make the DMP sustainable.
- Experience from one Disaster helps the community to strengthen their coping up mechanism to face another Disaster of similar kind.
- Last but not the least; human endeavor to prevent and mitigate disasters can be successful only on the help of an effective knowledge base. A country like India which is rich in knowledge, both traditional and modern needs to utilise this base for effective Disaster Management. The process of recording the data during any disaster situation has to be properly constituted for different type of disaster as each disaster situation is a unique event, which needs to be recorded for posterity to draw appropriate lessons.

# **HOSPITALS PREPAREDNESS FOR DISASTER: A CASE STUDY**

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## **ABSTRACT**

21<sup>st</sup> century after seeing the uncertainties of societal well-being has witnessed an increased low intensity conflicts. These conflicts are taking shape of man made disasters the most recent disasters of this nature are Sep.11 attack on WTC and Dec 9 attack on Indian Parliament. Disasters in any form whether man made or natural cause casualties & dislocation of different kinds of services which requires to be restored at the earliest not only to restore normal life pattern but also to bring down panic reaction at its lowest.

The various services, which need preparedness for any kind of eventuality coming without any warning, are health, sanitation, water supply, electricity supply, security (law & order), transport etc.

Health being the most crucial service, from the point of view of caring & rehabilitation of injured & disposal formalities for dead, requires the highest state of alertness round the clock all 365 days of the year without any relaxation of any kind for any reason.

As hospitals & emergency staff are the first persons to manage the consequences of any disaster, assessment of their preparedness is the most important for any government as well as public.

## **OBJECTIVE**

Keeping this view in mind this study was undertaken in the form of a case study so as to assess how prepared are the Indian health services.

## **SAMPLE**

Sampling was carried out in two stages. First the Indore city .an important industrial and educational centre of central India situated in the close vicinity of an important defense establishment of the country was chosen for this study. Then, ten hospitals representing the public, private & charitable sectors were selected for this study.

## **DATA COLLECTION**

Data were collected from CEO'S / Medical superintendents of the selected hospitals using a questionnaire developed for purpose of study. The questionnaire was in line with international protocols for preparedness of disasters.

## **RESULTS**

The study revealed that the studied hospitals presently are far from international protocols of preparedness for disasters. It was found that the awareness for preparedness is lacking.

The study has been able to highlight various factors where disaster preparedness is lacking & researchers have made a no. of suggestions to prepare hospitals for meeting with any challenge faced by them.

## **INTRODUCTION**

After the incidences of September 11 at world trade center USA, December 13 at Parliament of INDIA & the earthquake in state of Gujarat, INDIA, the importance of disaster management has become quite evident to even a lay person. As the tendency to take support of violence & threat to public life to highlight demands is increasing, no city in world can be said to be free from risk of facing such cowardly acts. So the responsibility of persons who tackle victims of disaster further increases along with the incidence of such unfortunate events whether those are man made or natural.

Obviously the first persons to deal with victims of any disaster are the emergency staff & the hospitals of that area. So it is quite logical for a hospital to be prepared to deal with disasters.

The problems in effectively dealing with disasters are manifold because accurate information and training is not readily available to emergency and disaster responders to meet the challenge effectively.

Concern about disasters is becoming increasingly relevant as increases in population density, population shifts, and increasing technology make it likely that we will encounter disasters more frequently and that they will be more severe (Drabek, 1986:60, 70) There are several reasons for this:

1. Increasing Population Density: as areas become more densely populated, there are more potential victims when a disaster strikes
2. Increased Settlement in High-Risk areas. There is greater settlement in high-risk areas such as flood plains, earthquake faults, coastal hurricane areas, unstable hillsides, areas subject to wildland fires, and areas adjacent to hazardous waste landfills, airports, and nuclear power

## **EXAMPLES:**

1. Each year floods cause loss to human & financial assets to the tune of millions in states of Bihar, eastern U.P. & Assam in our country.
2. Increased possibility of terrorist attacks in form of explosives, chemical, biological or radiological weapons is posing threat to almost all of democratic countries of the world.
3. More vulnerability of society to ethnic violence due to decreasing adjustability & political interference which leads to horrifying incidences like Godhra mass killing & its aftermath in INDIA. Which has incurred us cost to the tune of billions of rupees & of course lives the cost of which cannot be estimated at all.
4. There is a proliferation of high-rise office buildings and hotels that subject their inhabitants to fire threats not experienced before.

## **OBJECTIVES OF STUDY**

The objectives for this study are:

- To study level of preparedness for disaster in hospitals in Indore.
- To suggest for bridging out various gaps found while conducting this study.

## **RESEARCH DESIGN:**

The purpose of the study has been to assess how well the Indore Hospitals are prepared for managing the disaster. Therefore, the study has been planned on the basis of Survey research design where in the research shall lead to the conclusion whether the Indore hospitals are adequately prepared to face any kind of eventuality involving a large number of casualties and injuries requiring immediate care.

## **SAMPLE DESIGN**

In order to obtain the representative information from all the hospitals including the upcoming hospitals whose construction is in progress. For the study various hospitals were selected on the basis of their size, location & current working status. The schematic plan for the selection of hospitals was as follows:

Firstly, the hospitals were grouped on the basis of the number of beds available to patients for treatment as an indoor patient. They were classified into Two categories, viz..

- A) Hospitals with bed capacity of more than 100 beds.
- B) Hospitals with bed capacity less than 100 beds.

Secondly, the hospitals with less than 100 beds capacity were further selected on basis of there location so as to represent almost all the areas of the city i.e. the four areas (demarcated as north south east & west) of the city.

## **TOOLS**

The information for the evaluation of preparedness of Indore Hospitals for any eventuality was obtained through the questionnaire named as *Hospitals Preparedness for Disaster Management*, developed on the basis of guidelines from various resources including JCAHO (joint commission for accreditation of health care organization) and the personal discussions with the various experts in disaster management.

The questionnaire developed for the study contained mainly dichotomous items.

There were few open-ended questions also to help respondents give their preparedness in terms of the information, which could not be elicited through dichotomous questions.

## **ANALYSIS AND DISCUSSION**

Information received from following hospitals regarding preparedness for disasters was subjected to the analysis:

### **Hospitals which are providing services**

1. Maharaja Yeshwantrao Hospital
2. T.Choithram Hospital & research centre,
3. CHL-Apollo Hospital
4. Cloth market Hospital
5. Verma union hospital
6. Unique Hospital
7. Anand Hospital
8. Suyash Hospital
9. Lifeline Hospital
10. Mayur Hospital

### **Hospitals likely to start providing services soon**

1. Bombay Hospital & research
2. Arihant Hospital

The respondents comprised of CEOs, Administrative Officers, Managers or Superintendents of the respective hospital. Only one respondent was included in the sample.

It was found that only Four respondent Hospitals comprising of Three from Private Sector and Only One from Public Sector have developed or are in the process of developing some kind of infrastructure to meet with the Disaster situation, but that too in normal routine manner.

These Disaster preparedness programs are meagerly available to public and are far from the JCAHO criterion.

Public Hospitals in Indore city are the largest in terms of facilities and services provided by any hospital both private as well as public sector. The main Public sector hospital has some disaster related preparedness, possibly due to the fact that the hospital receives a large number VIP Visitors, whose security is quite important. The hospital though requires to make adequate arrangements to meet any eventuality, but it has not been able to meet the requirements.

Responses received from the respondents reveal that:

**PRESENCE OF ADQUATE DISASTER PLANNING COMMITTEE:**

Only 10% of the respondent hospitals have such disaster planning committee, to review time to time the hospitals' effectiveness in dealing with the eventualities.

**STAFF ORGANIZATION FOR DISASTER RESPONSE:**

Only 10% hospitals have some staff to meet the eventualities. Probably such a lukewarm response to the appointment of a skilled staff to meet the disaster is due to the fact that the City is yet to face a major disaster requiring specialized staff.

**ADEQUATE SPACE FOR TREATING EMERGENCY PATIENTS**

In spite of the fact that only 10% hospitals have disaster preparedness but 20% of the hospitals have adequate space for treating mass casualties.

**ADEQUATE SUPPLIES DURING DISATER**

Since all hospitals have a facility of providing medicines to patients they keep sufficient inventory of medicines and the same can be utilized for Emergency purposes. This facility of adequate supplies is available in 30% of hospitals.

Criterion for Indoor- patients in case of emergency situations demanding extraordinary space for the treatment of patients.

**EXTERNAL COORDINATION AND CONDUCTION OF DISASTER DRILL**

Of all the hospitals included in the sample, no hospital has any kind of external coordination and conduction of disaster drill. Probably, they do not engage themselves in such an activity because they do not feel it to be time and cost effective exercise and also they feel that in case of any disaster situation they will be able to meet the situation with the existing training and expertise of the staff.

**CONCLUSION**

Out of twelve Hospitals (ten in working status & two to resume working in near future) only four hospital have some system for disaster management but only one (public hospital) has adequate infrastructure for management of disaster.

Not only do people sometimes fail to learn from the mistakes of others, but also they may even neglect to correct their own, previously noted deficiencies, that is why the preparedness of hospitals in regard to Disasters gets the lowest priority.

**SUGGESTIONS**

In order to prepare the hospitals for any kind of disaster situation, there is a need to implement the following:

- Reducing apathy towards disaster preparedness through developing positive thinking for any kind of eventuality. The apathy needs to be tackled on three fronts:
- Public Education to make aware of the consequences of the disasters
- Media awareness to inculcate positive and receptive attitude towards disaster preparedness
- School programs to educate young children of the ill effects of the disasters.
- Planning Check Points : This is required to assess the possibility of disasters and their magnitudes.
- Paper Plan Syndrome: The disaster plan besides being put on the paper it requires adequate training and periodical exercise by the concerned staff.
- First Wave Protocol: The possible emergencies needs to be classified in accordance with the Committee on trauma of the American college of Surgeons in selection of facilities required for different categories of casualties and their awareness among staff as well as other hospital staff.
- Routing exercise of patients in a previously decided number according to the nature of injury, facilities available in hospitals and the availability of attending staff needs to be carried out and a proper information should be made available to emergency responders.

#### **INTER ORGANIZATIONAL PERSPECTIVE**

Even if all the hospital are equipped with the well-designed disaster plan, they may ignore coordinating with other hospitals, public safety agencies and most important of all disaster experts who have done some kind of study or work.

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# SEISMIC HAZARD ASSESSMENT IN DENPASAR – BALI

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## ABSTRACT

The high acceleration value in Bali area due to two sources zone: the Flores Backarc Thrusting and inter-intraplate subduction source zones. The thrust zone is evident in two segments: the Flores thrust zone in the west and the Wetar thrust zone in the east. Both dip opposite to the sense of subduction of Indian Ocean – Australian plate at the Jawa Trench and Timor Trough. The earthquake effects in Bali due to earthquake event are: ground shaking, liquefaction, ground failure and tsunami. The assessment was based on historical data as well as from deterministic hazard analysis considering maximum magnitude that could be generated from potential faults and subduction source zone. The assessment was also based on previous seismic hazard analysis available in the literature. The assessment provides peak ground acceleration (PGA) at baserock of values in the range of 0.25 – 0.4 g.

## 1.0 INTRODUCTION

Indonesia is a country where four of the earth's main plates contribute to the seismic activities in the region. This condition has caused most of Indonesian regions are potential to relatively high risk to earthquake. City of Denpasar is the capital of Bali Province is considered one of the most densely populated cities in this province. Regional earthquake map shows that north of Bali – on the west and East Nusa Tenggara on the east side has one seismic source zone called Flores Back Arc Thrusting. This fault has historical earthquake activities such as the 1976 Seritit Earthquake and the 1992 Flores Earthquake. Other earthquake sources are interplate and intraplate subduction seismic source zone, such as: the 1862 Buleleng Earthquake, the 1890 Negara Earthquake, caused walls and tumble down and reached VII MMI.

## 2.0 REGIONAL TECTONIC SETTING

The major tectonic feature in the region is the Sunda Arc, which extends approximately 5,600 km between the Andaman Island in the northwest and the Banda Arc in the east. The island arc results from convergence and subduction of the Indo-Australian plate beneath Southeast Asia. The direction of plate convergence between Southeast Asia and the Indo-Australia plates is assumed to be about north south and overall rate of convergence is probably about 7.7 cm/year. Based on the inferred direction of plate motion and geologic evidence, the relative motion appears to be normal to the arc at Jawa-Bali, and oblique near Sumatera. The normal driving of the underthrusting plate to the overriding plate is accommodated thrust fault system (the Flores Backarc Thrusting) in the forelands of continental arc.

### 2.1 Java – Bali Segment of the Java Trench

The subduction zone south of East Java – Bali and Nusa Tenggara Barat:

The Java segment of the Sunda Arc extend from Sunda strait on the west to Bali Basin on the east and relatively old oceanic crust (150 mY) is converging in a direction essentially normal to the arc at a rate of about 6.0 cm per year in the west Java Trench and 4.9 cm per year in the East Java Trench (Soetardjo, 1987). The Benioff Seismic Zone along this area study dipping approximately 40° and extends to a depth of approximately 350 km changes to 50° at a depth of 600 km and a gap in seismicity exist in this segment between depth of 350 km.

The Nusa Tenggara Barat is seated in roughly transitional Zone between the Banda and Sunda Areas: the discontinuity is marked by series of negative gravity anomalies, a noticeable difference in the pattern of seismicity, geochemical difference in the volcanic rocks, and sub-marine geomorphology differences (Katili and Hartono, 1983). The discontinuity reflects the change in character of converging Australian Plate from Oceanic lithospheres in the west to continental crust in the east.

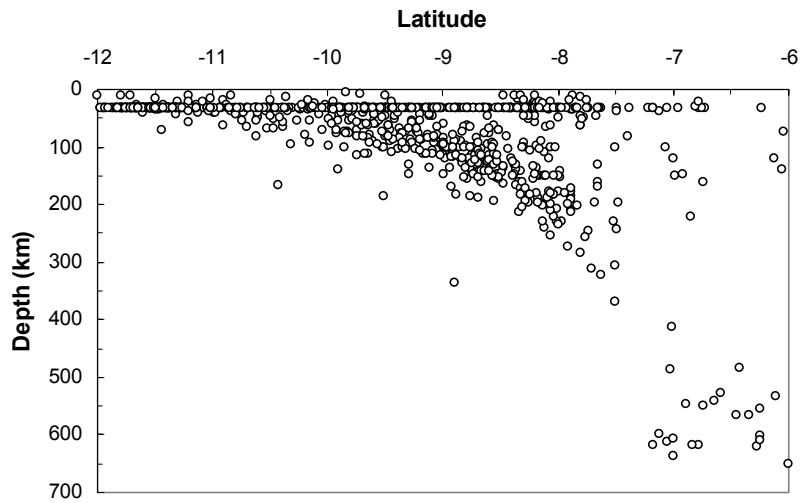


Figure 1 Hypocenter profile of Bali Segment of Java Trench

**2.2. Flores Back Arc Crust Thrust Fault.**

The thrust zone is evident in two segments: the Flores thrust zone is the west and the Wetar thrust zone in the east. Both dip opposite to the sense of subduction of Indian Ocean – Australian plate at the Jawa Trench and Timor Trough. The most recent earthquakes due to this seismic source zone the Seririt Killer Earthquake in 1976  $m_b$  6.1. No earthquakes that are clearly associated with the back arc thrust zone have been found deeper than 25 km (McCaffrey and Nabelek, 1987). Figure 2 shows the shallow crustal faults around Bali Island.

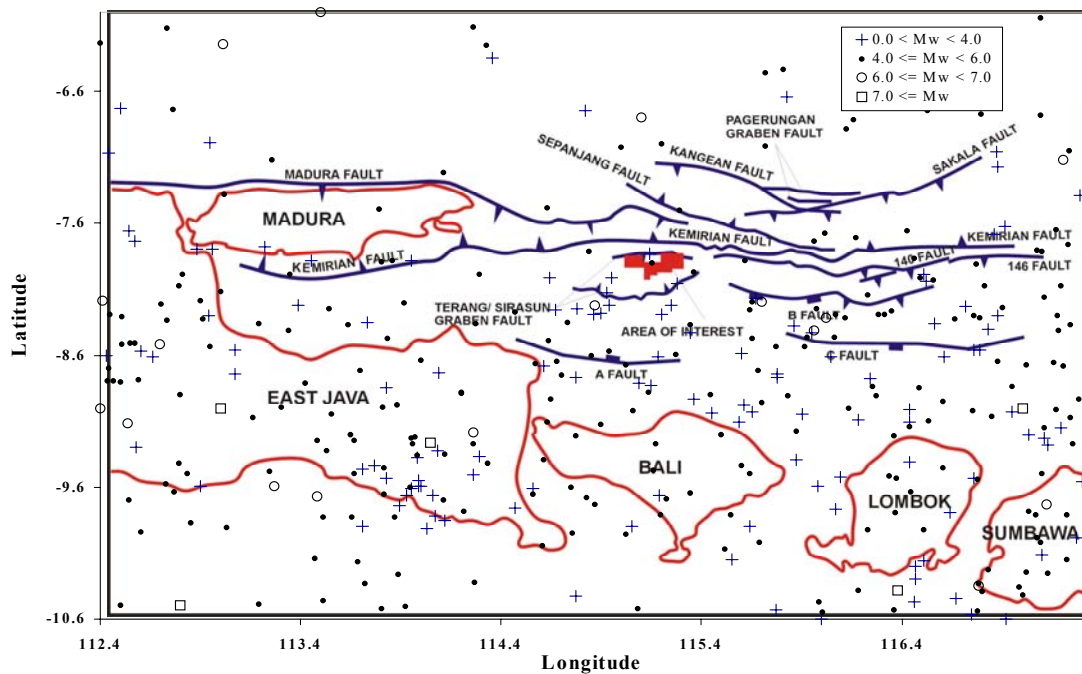


Figure 2 Shallow crustal fault around Bali island (Woodward-Clyde, 1997)

The Bali Basin occupies transition zone of the Sunda Arc. Banda Arcs, precisely South of East – Java and West of Flores Basins (Prasetyo and Sarmili, 1994). The Bali Basin is deep-sea sedimentary basin with a size of 100 km x 200 km, narrowed to the east and reached its maximum depth of slightly below 1500 meters (Kusnida, et al., 2000). And the Bali Basin is hanked by the Tertiary Java Basin to the west and the oceanic Flores-Basin to the east and thus provides an actualistic setting for the development of

fold and thrust belt. The crust of the Bali Basin was transitional in thickness between oceanic and continental (Hamilton, 1979). The fold and thrust belts develop in the foreland of Continental arcs have been observed the dip angle of the subducting plate so that inferences about the deformation. The thrust belt is evident in the two segments: the Flores thrust zone in the west and Wetar Thrust Zone in the east and by one arc micro thrusts that may represent early by stages of subduction polarity reversal in the area (Nishimura & Suparka, 1985).

In the north, it is limited by an east-west trending Madura-Kangean High, which is acting as the Southeastern border of the Sunda land. The southern part of this ridge is limited by an east west trending, Sepanjang Normal Fault (Letouzey, et al., 1990). In the east, the northwest-southeast lineation bathymetric Contour is presented as the eastern limit of the basin, and convinced to be continuing to the Saleh Bay depression in Sumba Island (Zen et al., 1992). The Bali Basin receives sedimentary infill from the north (Sunda shield), from the west (Madura strait) and principally from the south (Bali-Lombok). Around the longitude (114.60°-7.60° S) at 5.5 km depth, Kusnida et al. (2000) observed the 30 km x 40 km dimension of doming of Moho physical discontinuity with east-west direction. Selater and Menard (1967) state that such structure indicates the up-welling of hot mantle material beneath active marginal basin although of lack coherent spreading center typical of normal mid ocean ridges. Kusnida et al. (2000) suggest that it would be the initiation of back arc thermal stressing. A zone of huge slumping in the affinity area probably indicates a sea-floor expression of this deep-seated up-doming structure (Kusnida et al., 2000).

In this area, surficial slump sears like structures seems to be formed by differential up lift of the basement underneath. Back-arc thrusting in this area causes the structures tend to be grouped into two main categories, as said above: those due to tectonic forces, magma intrusions (Silver et al., 1983), and collision by Roo rise. Magma activity is probably important in weakening the thrust, however and in this way aiding thrust development in the collision region.

The west part of Flores Thrust is the Bali Basin. It is narrow and shallow, and underlain by oceanic crust (Raitt, 1967; Hayes et al., 1978). But Silver et al. (1983) suggest that the Flores Thrust is disappearing beneath the Bali Basin. The deepest part of the basin is along the south margin, and although it is filled with sediments, (see above). Neotectonic for the study area/east Indonesia, it is assumed that the majority of the shoreline features are result of Quaternary diastrophic, due to active tectonic movements and seismicity. And the Pleistocene period (2.5 million years ago) in Indonesia was characterized by powerful mountain building. In some areas the orogenic movement was started in Pliocene Time (seven million years ago) and in many parts it continued into Holocene and Resent Time such as in this area Terraces distribution in north coast of East Nusa Tenggara (Central Flores to eastern Sumbawa) are high on the north Coast and low or absent on the south due to North-South tilting of Flores Island. All group in the northern Flores have sunk in Pleistocene Time (2.5 million year ago) and estimated to have a rate of 1 mm per year. The up lift of Timor at a rate of 0.37-7.0 cm per years and the other outer islands to the east due to the positive buoyancy to continental crust beneath the accretion wedge (Silver et al., 1985). The estimate rate of fracture zone movement in the north of Bali is approximately 0.1 to 0.3 mm per year.

### **3. EARTHQUAKE HISTORY**

The most recent earthquake felt in Denpasar is the Karangasem Earthquake, December 17, 1979. Significant damage was reported. 25 people person killed, more than 400 people seriously injured. Cracks in the road and land were observed along 0.5 km. The oldest damaging earthquake recorded in this area was 1862 March 29, Buleleng Earthquake MMI VII. The source of this earthquake is the interplate subduction zone.

Earthquake in Seririt in 1976 July 14, in Tabanan and Jembrana more than 75 % buildings and houses severely damage 559 killed, 850 people seriously injured and some than 3200 injured. MMI VIII.

There were major large earthquakes reported in historical record prior to instrumental recording (NewComb and McCann, 1987). These events occurred in 1840, 1867 and 1875. Several large events were also recorded since 1903. The record of historic seismicity along the Java segment indicates that

within a period of about 300 years, no great intraplate earthquake have occurred that were similar to the 1833 and 1861 Sumatra events.

The significant earthquakes in this area were:

Tulungagung earthquake of 05 July 1859 (MMI scale of VI, some buildings and houses suffered damage), another Tulungagung Earthquake with a MMI scale of VII occurs on 20 August 1896,

Bali Earthquake of 21 January 1917: ground slumps and ground slides were observed at various places. Many houses suffered damage and about 1500 people were killed due to groundslides, the MMI scale of IX,

The Gresik Earthquake of 19 June 1950 (MMI scale of VII).

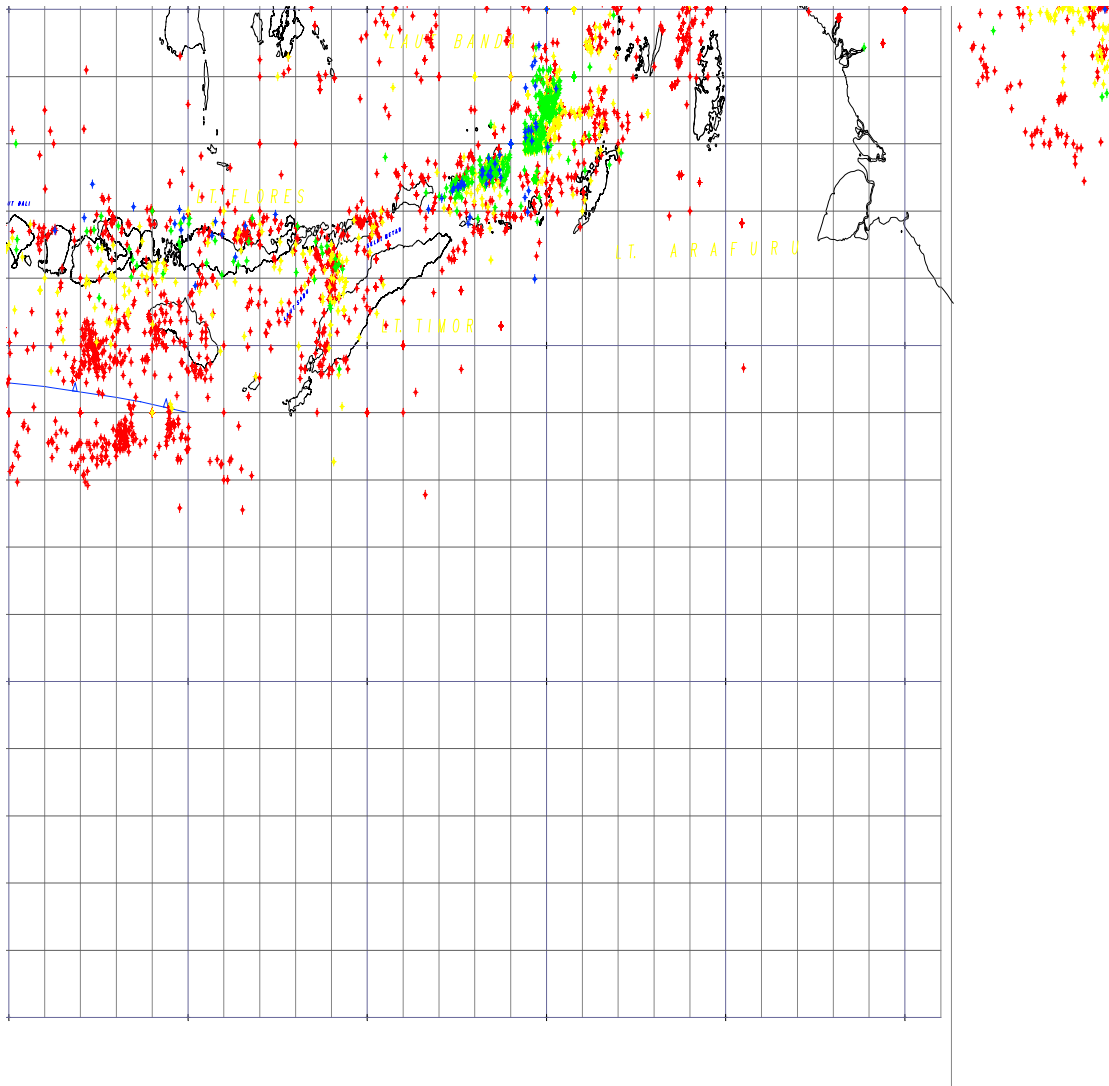


Figure 3 the earthquake distribution in Denpasar and vicinity area

Figure 3 shows the earthquake distribution in Denpasar and vicinity area. The study that had been conducted by Susila, 2000 as show in Figure 4, the maximum peak ground acceleration suggested around 0.30 g with return period 500 year.

The high acceleration value in Bali area due to two sources zone: the Flores Backarc Thrusting and inter-intraplate subduction source zones.

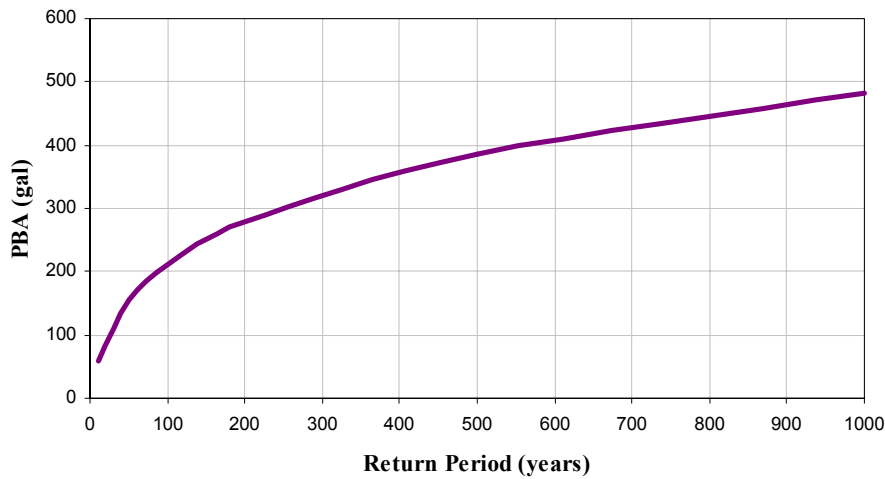


Figure 4 Maximum peak base rock acceleration for Denpasar (Susila, 2000)

**HAZARD ASSESSMENT**

Preliminary seismic hazard assessment has been performed for Denpasar municipality. The assessment was based on historical data as well as from deterministic hazard analysis considering maximum magnitude that could be generated from potential faults and subduction source zone. The assessment was also based on previous seismic hazard analysis available in the literature. The assessment provides peak ground acceleration (PGA) at baserock of values in the range of 0.25 – 0.4 g. The earthquake effects in Bali due to earthquake event are: ground shaking, liquefaction, ground failure and tsunami. Figure 5 shows ground surface map, Figure 6 shows ground fracturing potential map and Figure 7 shows liquification potential map

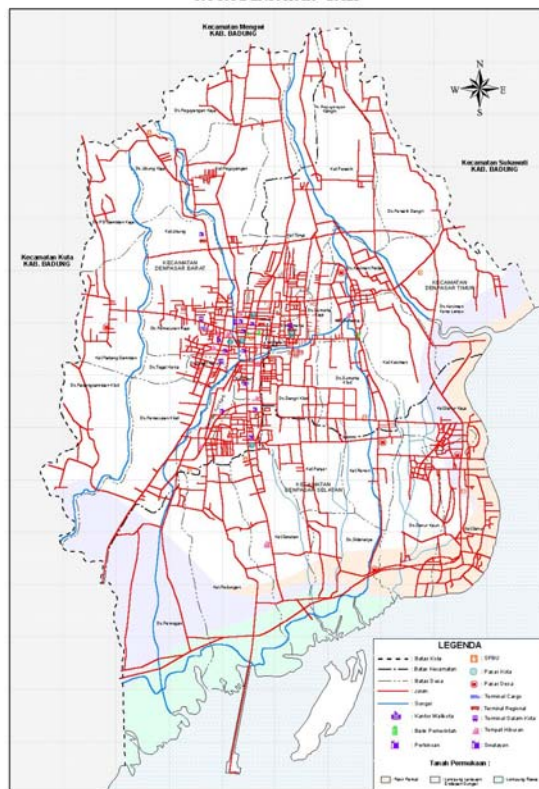


Figure 5 Ground surface map



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# **LANDSLIDE HAZARD AND RISK ASSESSMENT ON HILL COUNTRY OF SRI LANKA**

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## **ABSTRACT**

The Central Highlands of Sri Lanka underlain by highly folded and fractured metamorphic rocks of different grades of weathering have a high probability for landslides and rock-falls. Intense precipitation is a major factor contributing to the landslides. Despite repeated occurrences of landslides in Sri Lanka inflicting losses in terms of life and property, very little has been done towards introducing scientific practices for delineating the degrees of hazard, identifying elements at risk, and landslide risk assessment. A National Building Research Organization (NBRO) has already commenced production of landslide hazard zonation maps covering the areas prone to landslides. The total vulnerable area is estimated to be around 10,000 km<sup>2</sup> in seven administrative districts in the Central Highlands. The phase I of the program which was supported by the UNDP/UNCHS was ended in July 1995. It helped to build institutional capacity in landslide hazard management and to produce maps covering two most vulnerable districts. Subsequently the Government of Sri Lanka has taken an important decision to continue the program into other landslides prone districts. Those maps and data are expected to provide an essential input to the risk assessment. The present study was based on an investigation carried out in Yatiyantota area at Kegalle district. The area was severely affected by the landslide incidents that occurred in 1997 during the north - west monsoons. The landslide risk assessment is expected to facilitate determination of risk through scientific analysis of landslides. Development of a culture for, assessment of risk before commencement of major infrastructure development projects and establishment of human settlements in landslide prone areas based on the risk criterion will be essential for sustainable development of the central hills of Sri Lanka.

## **INTRODUCTION**

The hill country of Sri Lanka, underlain by highly folded and fractured metamorphic rocks has a high probability for landslides. Intense precipitation is a major factor contributing to the occurrence of landslides. 1986/89 major landslide disasters, promoted the Government of Sri Lanka to take serious note of the losses and initiate appropriate measures for reduction of the impact of landslide disasters. As a result the National Building Research Organisation under the Ministry of Urban Development, Housing and Construction supported by the United Nations Development Programme (UNDP) and United Nations Center for Human Settlements (UNCHS) for a building of institutional capacity in the field of landslide studies and services. Landslide hazard zonation of central hill country of Sri Lanka made a start in 1990 under the Landslide Hazard Mapping Programme (LHMP). The phase I of the program ended in July 1995 and with that the UNDP/UNCHS assistance also came to an end. But the Government of Sri Lanka has taken an important decision to continue the program into other landslides prone districts.

Hazard is confined to the expected occurrence of landslide, while risk involves the expected damage consequences of landslides (lost of life or injured persons, cost of property and infrastructure facilities etc.). The engineering analysis of landslide risk has essentially two components, the probability of occurrence and the resulting consequences. In Sri Lanka, very little has been done towards introducing scientific practices of landslide risk assessment delineating the degrees of hazard, identifying elements at risk, risk assessment and risk treatment. Landslide Studies and Services Division (LSSD) of NBRO has already produced a set of landslide hazard maps and Sri Lankan landslide database. These maps and data would provide an essential input to the risk assessment. The landslide hazard zonation map is delineates area with different probability for initiate landsliding. But these maps are not available for every area of the landslide prone hill country. This paper describes application of philosophy of landslide risk assessment without using data from landslide hazard zonation map of the area.

Selected site for the study at Yatiyantota is situated in the Kegalle district. Due to heavy rain, bank failures, cutting failures, gully erosion and small landslides occurred on 16 September 1997 at about 2.30 a.m. The recorded rainfall on 16th was 250mm/day. The unstable area covers about 2km stretch along the left side of the main road from Yatiyanthota town to Aliwatta village. It is easily accessible by Awissawella- Hatton main road (Location map Fig.1). Due to this failure, 4 houses were completely destroyed, 7 houses were partially damaged and 13 houses within the vulnerable area are threatened by future failures. However no human losses were recorded perhaps as a result of awareness created about the causative factors and about the importance of observance of constant vigilance during heavy rains by NBRO under LHMP. It's a known fact that the small- scale landslides can be developed into a disastrous landslide event subsequently during monsoon seasons, if timely actions are not taken for remediation.

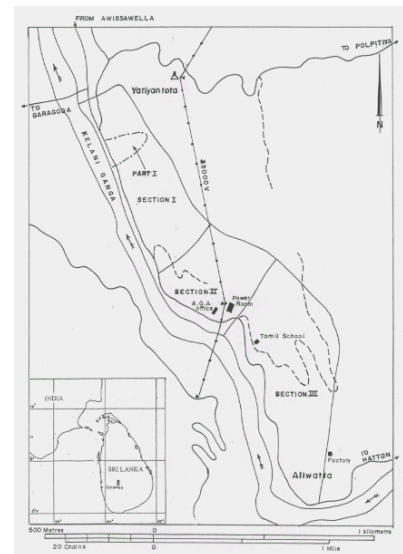


Fig.1 Location map of Study Area

## RISK ASSESSMENT FOR SLOPES VULNERABLE TO LANDSLIDES

Landslide risk assessment can be practiced at various levels of detail, ranging from qualitative evaluations to detailed quantitative risk analysis. The method to be used will depend on the level of study. For natural slopes, semi quantitative methods are more likely to be applicable. The main principle that applies to assessment of natural hazard is “past and present are keys to the future”. Hence it is most likely that landsliding will occur where it has occurred in the past and landslides are likely to occur in similar geological, geomorphological and hydrological conditions as they have in the past. The landslide risk assessment for an individual slope, there is a need to consider each of the following components (a) Hazard identification and probability of occurrence. (b) Elements at risk (c) Estimation of vulnerability of property and persons due to landsliding (d) Calculation of total risk. The total risk ( $R_t$ ) is the expected number of lives lost, persons injured, damage to property and disruption of economic activity. It is the product of specific risk ( $R_s$ ) and elements at risk ( $E$ ) over all landslide and potential landslides in the area.

$$R_t = \sum_{i=1}^n R_s \cdot E = \sum_{i=1}^n P \cdot V \cdot E \quad (1)$$

Where;  $R_t$  - total risk,  $R_s$  - specific risk (Probability x Vulnerability for a given element),  $P$  - probability,  $V$  – vulnerability,  $E$  - element at risk (e.g.: person, building, infrastructure etc.).

### Hazard Identification and Probability of Occurrence

The probability of initiate landsliding of a specific location could be determined using graded landslide hazard map of the area. If landslide hazard zonation map of study area is not available following semi-quantitative landslide risk assessment method was introduced. The method based on contributory parameters for landsliding. A relative weight (degree of importance) was determined almost similar to already developed and using for landslide hazard zonation mapping in landslide prone hill country (Table 1). For the demonstration of this method used case study in Yatiyantota probable landslide area. The result of field investigation of Part (A) of the Section (I) indicate the most vulnerable to future disaster due to landslide hazard. This area was selected for further studies and assessment of risk.

Table 1. Field checklist for ranking of landslide hazards (H)

G1 Bed rock geology and Structure (20)	Lithology (8)	0	Marble	3
		1	Weathered rock	
		3	Granite, Gt.bt.gn, all others	
		5	Charnockite, Granulite, NBE Quartzite	
	Amount and direction of Dip (8)	0	Dip and scarp 70-90	4
		1	Dip and scarp 55-70	
		2	Dip 10-30, scarp 45-55, inter.	
		4	Dip 0-10, scarp 30-45 Dip 30-55, scarp 0-30	
	Deviation Angle (6)	0	25-120	4
		2	10-25 or 120-155	
		4	155-180	
		6	0-10	
	Discontinuit ies (2)	0	Absent	2
		2	Present	
G2  Overburd en deposits (10)	Soil Thickness (10)	0	Bed rock	2
2		Coll < 1, overburden < 2		
8		Coll 1-3, overburden 2-8		
9		Coll 3-8, overburden >8		
G3 Slope angle (25)	Slope Angle (25)	5	>40°	25
		15	31°- 40°	
		25	17°-31°	
		20	11°-17°	
G4  Hydrolog y (20)	Piezometer level (ground water table) (20)	3	Below slip plane	15
		7	Above slip plane	
		10	Between ground level & slip plane	
		15	At ground surface	
G5 Landform and landuse (25)	Landform (15)	3	Simple slope (no previous slides)	12
		8	Simple slope with surface cracks	
		10	Old slip but modified by erosion	
		15	New slip now stable no erosion Recent slip, erosion at toe	
	Landuse (10)	1	Natural woods	10
		2	(undisturbed)	
		3	Cleared and cultivated well	
		5	Cleared for pasture land	
		7	Disturbed by cattle	
		8	Controlled construction	
100	Total score	100	Heavy construction	77

According to Table 1 calculation pointed out the Part (A) area of Section (I) has a hazard factor H is 77. According to Table 2, this area was identified as most hazardous area. The probability for landsliding is

likely <95%. According to past historical records in hill country of Sri Lanka, annual general probability for disastrous landslide in most hazard area is  $10^{-2}$ . Assuming 50% probability for landslide occurs within the study area and, according to total probability theory, annual probability for landsliding in part (A) is  $0.5 \times 10^{-2}$ . Also the field investigation helped to identify probable landslide boundary and type as landslide cum debris flow.

Table 2. Relationship between hazard and probability of landslide occurrences

Hazard Range	Qualitative Term used in Hazard Zonation	Probabilistic Criterion Grade	Indicative Annual Probability
$H \leq 40$	Safe Areas	Very Unlikely <5%	$10^{-5}$
$41 \leq H \leq 55$	Moderate Hazard	Unlikely 5-20%	$10^{-4}$
$56 \leq H \leq 70$	Hazard	Likely 20-80%	$10^{-3}$
$71 \leq H \leq 100$	Most Hazard	Very Likely >95%	$10^{-2}$

**Element of Risk**

When the probable landslide boundary is super imposed with the human settlements and infrastructure map it was observed that (Part “A” of Section I) following human and properties are vulnerable to future landslide events (Table 3).

Table 3. Elements at risk in Yatiyantota potential landslide

Area of the landslide	Element at risk	Property value <sup>1</sup> (Rs.)	Person Value <sup>2</sup> (Rs.)
Head region	2 houses/ 7 person	1000000	7 x 150000
Main body	5 houses/ 20 person 50m footpath	5000000 100000	20 x 150000
Foot	1 house/ 5 person 20m foot path 2 shops/ 20 person 1 church/ 50 person Telephone Exchanger	700000 50000 3000000 2000000 1000000	5 x 150000 20 x 150000 50 x 150000
Toe	1 house/ 3 person 125m highway	700000 1250000	3 x 150000 2 x 150000

<sup>1</sup>Property value is taken by considering the land, type and condition.

<sup>2</sup>Although humans cannot be valued, since study required a figure to calculate the amount of Rs. 150000.00 are considered. It is an amount paid by insurance and average was considered.

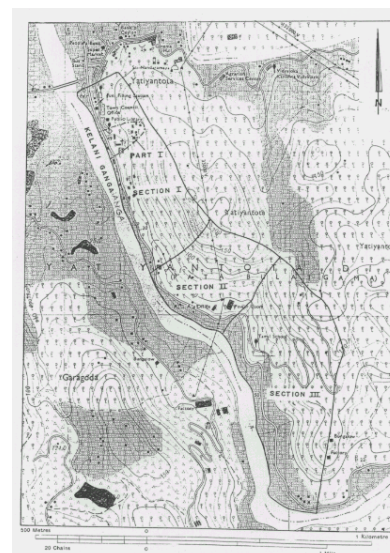


Fig.2 Human Settlements and Infrastructure

**Estimation of Vulnerability due to Landslide Hazards**

Although the state of the art for identifying the elements and their economic value is relatively well developed, the state of the art for assessment of vulnerability is in general primitive. The vulnerability is the degree of loss to a given element or set of elements within the area affected by the landslide. It is expressed as a scale of 0 (no loss) to 1 (total loss), which are likely to have been determined from previous experience or expert judgment. Vulnerabilities of property and persons were estimated for the study based on the past landslide history and expert judgment. The assumed values are given in Table 4.

Table 4. Estimation of landslide vulnerability for property and persons

Area of the landslide	Factors	V <sub>Property</sub>	V <sub>Persons</sub>
Head region	High velocity, medium depth, little warning, short escape distance	0.7	0.3
Main body	High velocity, high to medium depth, little warning, long escape distance	1.0	0.5
Foot	Medium velocity, debris accumulation, some warning, short escape distance	0.4	0.01
Toe	Low velocity, more warning, short escape distance, debris flow < mud flow	0.1	0.001

**Calculation of Total Risk**

Annual total risk (R<sub>t</sub>) could be calculated as from Eq. (1),

$$R_t = \sum_{i=1}^n P.V.E$$

$$R_t = \sum_{i=1}^4 R_{property} + \sum_{i=1}^4 R_{person}$$

$$R_t = (R_{Head(property)} + R_{Head(person)} + R_{Body(property)} + R_{Body(person)} + \dots)$$

$$R_t = [ (0.05 \times 0.7 \times 1000000) + \{(0.05 \times 0.3 \times 150000)7\} + \{0.05 \times 1.0(5000000 + 100000)\} + (0.05 \times 0.5 \times 150000)20 + \{0.05 \times 0.4(700000 + 50000 + 3000000 + 2000000 + 1000000)\} + (0.05 \times 0.01 \times 150000)75 + \{0.05 \times 0.1(700000 + 1250000)\} + (0.05 \times 0.001 \times 150000)5 ]$$

$$R_t \approx 0.5313Rs.Million$$

Therefore annual total risk in the potential landslide area is 0.5313 Million Rupees (In August 2002 general currency exchange rate of 96.00 Sri Lankan Rupees equal to 1U.S \$)

**Limitations of the Landslide Risk Assessment**

As seen in the study, there are a number of limitations to risk analysis and assessment for slopes and landslides;

- The judgments, content of the inputs may well result in values of assessed risks with considerable inherent uncertainty. More experience and understanding of the process may improve the reliability of the assessment.
- The variety of approaches that can reasonably be adopted to assess the landslide risk can result in significant differences in the outcome if different practitioners consider the same problem separately.
- Revisiting an assessment can lead to significant change due to increased data, by application of a different method or changing the circumstances.
- The inability to recognize a significant hazard and the consequential underestimation of the risk.
- The methodology is currently not widely accepted and thus sometimes there may be an aversion to its application.

**CONCLUDING REMARKS**

Development of culture for risk analysis before commencement of major infrastructure development projects and establishment of human settlements in landslide prone areas based on the risk criterion is desired to be considered as an essential factor for sustainable development in areas prone to landslides in hill country of Sri Lanka.

The methodology for risk assessment given in this paper will facilitate determination of risk through scientific analysis of landslide hazards in future. The expected total risk due to landslide disaster, cost for mitigation actions and loss prevention costs may also be calculated through the given methodology. It is expected to help non-technical decision-makers to assess the situation before taking appropriate futuristic measure. This methodology may be used for assessment of the risk in any landslide prone area in central highlands provided that sufficient basic data is available for assessment. The application areas of proposed methodology are very wide and decision-making by authorities (Provincial Council, Local Government Institutions, Insurance Companies, Lending Institutions etc) as well as individuals (affected families, victims, businessman etc) may be based on results obtained through assessments using the proposed methodology.

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