

Living with Earthquake in South Asia: Multi-pronged Strategy Required for Preparedness, Prediction, Surveillance, Structural Reinforcement and Insurance

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State of Disaster:

Over the past decade, the number of natural and man-made disasters has increased significantly. The types of disaster, their intensity and frequency have increased manifold over the past few decades (Table 1). The biggest increase was observed in countries of low human development, which suffered an increase of 142 per cent. This is attributed to population increase and standard of living. Of the total geographical area, 85 per cent of India's land is prone to various kinds of disasters. Of this, nearly 59 per cent of the Indian land mass is susceptible to seismic hazard (moderate, high and very high zone). Dangers from earthquakes in the Himalayan region in general and South Asian mega-cities in particular are very high (Figure 1). This is exacerbated due to the dense clusters of population, lack of awareness and prevalent poverty. As recent earthquakes in Nepal and India caused large scale loss of human life and damage to properties through direct and indirect impacts like faulting, cracks, upheaval, subsidence and dislocation etc., it is high time to give foremost importance of disaster prediction, monitoring and mitigation.

With the help of super-imposed images of population distribution, population density, seismic activities and vulnerability, it is reflected that the maximum areas of Himalayan region are most susceptible to earthquakes. Many large cities are also situated in the foothills of Himalaya and posing high level of risks in urban environments. Multiple minor plate boundaries in the region can be traced (Figure 2 and 3).

The districts of Sindhupal chowk, Kathmandu, Nuwakot, Dhading, Bhaktapur, Gorkha, Kavre, Lalitpur and Rasuwa are most affected areas in Nepal. UNICEF announced that close to 1 million children were "severely affected" by the disaster. The death toll in Nepal has crossed 7,000. The Nepal Prime Minister, Hon'ble Sushil Koirala has said that the number could reach 10,000. The UN Agencies say that the earthquake affected about 8 million people out of 28 million people of Nepal.

Table 1: History of Major Earthquake Disasters in India

Name of the Event	Year	State and Area	Causalities
Mumbai Earthquake	1618	Mumbai, Maharashtra	2,000 deaths
Bengal Earthquake	1737	Bengal	300, 000 deaths
Himachal Earthquake	1905	Kangra, Himachal Pradesh	20,000 deaths
Bihar Earthquake	1934	Bihar	6,000 deaths
Uttarkashi Earthquake	1991	Uttar Pradesh	768 deaths and 5066 injured
Latur Earthquake	1993	Latur, Marthawada, region of the Maharashtra	7,928 people died and another 30,000 were injured
Gujarat Earthquake	2001	Bhuj, Bachau, Anjar, Ahmedabad, and Surat in Gujarat State	25,000 deaths 6.3 million people affected
Kashmir Earthquake	2005	Kashmir State	86000 deaths (includes Kashmir & surrounding Himalayan region)
Sikkim Earthquake	2011	North Eastern India with Epicenter near Nepal Border and Sikkim	97 death and wide spread landslide
Nepal and India Earthquake	2015	Nepal and Northern India	Over 7,000

Source: Various Reports.

**Seismic Zone
Map of India: -2002**

About **59 percent** of the land area of India is liable to seismic hazard damage

Zone	Intensity
Zone V	Very High Risk Zone Area liable to shaking Intensity IX (and above)
Zone IV	High Risk Zone Intensity VIII
Zone III	Moderate Risk Zone Intensity VII
Zone II	Low Risk Zone VI (and lower)

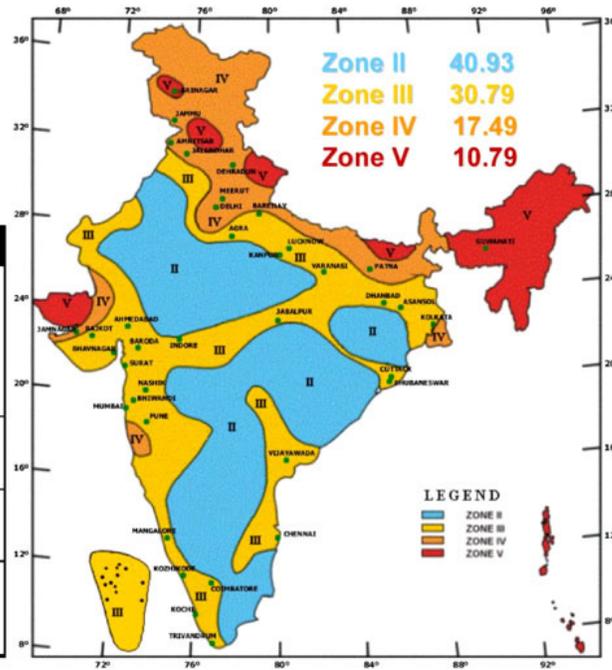


Figure 1 Seismic Zonation Map of India, Source: NIDM, India

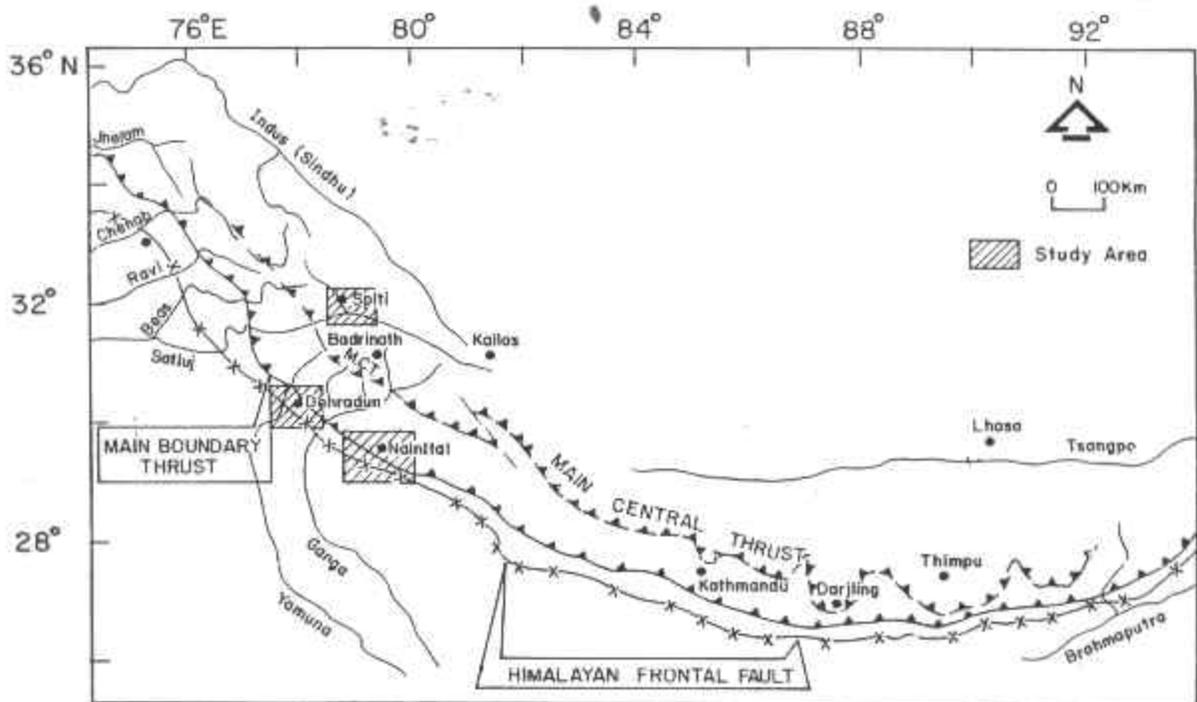


Figure 2 Main Fault Lines in Himalaya, Source: Banerjee et al., 1999

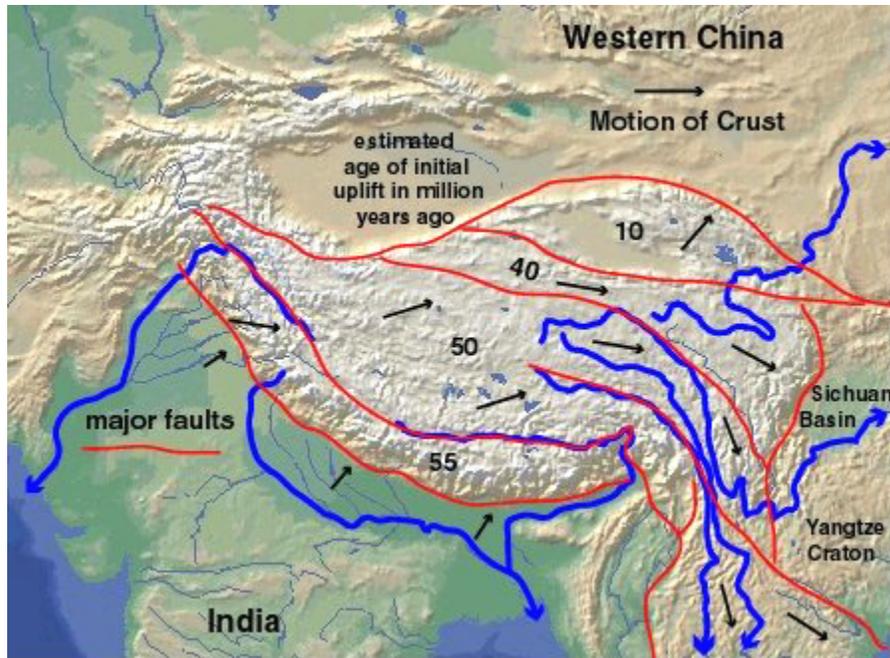


Figure 3 Direction of movement of plates, source: Clark Burchfiel et al.

Typical Mechanisms of Earthquakes in Himalayan Zone:

About 80 per cent of the world's seismic energy for shallow earthquakes as well as most of the energy in intermediate and deep focus earthquake are released at the plate boundaries (Figure 3). The Himalayan mountain range dramatically demonstrates one of the most visible and spectacular consequences of plate tectonics. This is known as convergent plate motions, where crust is destroyed as one plate subducts under another. The recent Nepal Earthquake is also a result of denser Indian plate subduction under lighter Eurasian Plate.

Vulnerable Structure and Materials Mapping Using Remote Sensing and GIS: More people die from building collapse than the tremors:

The historical locations and zone of influence of the earthquakes can be mapped using remote sensing and geographical information system to understand the trend and patterns of the disaster. The fault lines and lineaments can be monitored through Ground

Penetrating Radar (GPR) for micro-zonation mapping. This preliminary exercise along with the earthquake prone maps can be effectively utilized for disaster preparedness and mitigation. It is well-known fact that more people die from building collapse than the tremors. It is said that mud houses own by poor people kill more people and cement houses own by rich people save people. This fact is applicable for all the less developed countries like Nepal. In this context, strict rules regarding construction locations, material and technology are needed for reducing the deaths from building collapse.

Techniques for Earthquake Prediction:

Scientific: Many scientists like French, Japanese and other scientists of few other developed countries have used satellites data for earthquake prediction. We must use and explore the viability of Synthetic Aperture Radar (SAR) sensor data. The study has taken into account actual imaging of the earthquake with the help of ERS-1 satellite. Another technique of the morpho-structured zoning map preparation of the entire country through Geodetic Very Long Baseline Interferometry (VLBI) in order to estimate the hazard accurately and thereby make adequate warning possible. Pattern Mapping of Earthquake cycle may be also useful for predicting earthquake.

Cultural- Due to movement of animals, ants and birds, a few extreme events i.e. earthquake were predicted in some countries and loss of human lives were reduced. I would like to mention here that unusual behaviors were found among elephants in Sri Lanka during last Indian Ocean tsunami.

Earthquake Surveillance:

This system will help a better understanding of the location and interaction of seismogenic structures, which allow to target in a more proficient way the routine activities of seismic monitoring. Selection of appropriate seismogenic zones based on regional tectonic, geologic and physiographic features and the regional historical seismicity patterns.

Refining the Seismic Micro-zonation: Earthquake Hazard & Risk Assessment (EHRA) unit is currently engaged in refining the seismic micro-zonation in India particularly of NCT, Delhi on 1:10,000 scale. Action has also been initiated for taking up micro-zonation of other important cities of South Asia under Bureau of Indian Standards IS-1893 – part – 1: 2002. It is important to incorporate education, level of poverty and awareness in this process.

Lessons Learned: Is Delhi and other Mega Cities of South Asia Prepared for Earthquake? - Agenda before Government and Communities of South Asia:

Delhi is experiencing frequent tremors in recent days. Many people believe that energy release through these tremors reduces the risk for earthquake but this assumption is not based on definite proposition. Based on assessment of poor status of earthquake preparedness and delaying in response of the government in dealing with rescue and relief operations in past earthquakes, the need of the hour is to review the vulnerability maps of the city. Delhi is presently in Zone IV of seismic zones of India. The magnitude of the probable earthquake will range between 5 to 6 Richter scale which could be extremely devastating in the present state of preparedness in Delhi. The loopholes are both in the physical structures like houses, buildings, old bridges, heritage monuments etc. and human awareness is extremely poor in regard to earthquake related information in view of evacuation, prevention, emotional development etc. Following do's should be kept in mind while preparing an earthquake preparedness plans and policies in Delhi:

Monitoring epicenter of the east regularly: Considering existence of Fault Zone in Eastern Side of the Delhi and Dadri in UP, it is necessary to monitor regularly.

Retrofitting of old buildings: It is difficult and expensive to built all new structures in Old buildings so it is important to incorporate safety measures by incorporating pillar and Beam support in present buildings by providing with the fire safety measures and suitable protection fittings for expensive items.

Strict implementation of building codes for construction of new houses and buildings: All new houses that are being constructed or will be constructed should follow earthquake resistant Building codes. Clearance certificate should be only issued when the

buildings are safe from any kind of disaster. Special care relating to earthquake resistant building should be made while constructing hospitals, schools etc.

Assessment of landscape synthesis for building construction in trans-Yamuna areas:

Land suitability evaluation should be done before construction of high rising buildings and housing complexes particularly in trans-Yamuna areas. Flood plains, reclaimed waterlogged areas, geologically weak areas should be avoided for construction of high rising built up structures, instead these areas should be used for construction of recreational activities like parks, stadiums, picnic spots or single storey buildings which are made by strictly following building codes.

Development of open spaces for safe shelter particularly in Old Delhi, Paharganj Karol Bag, Jahangir Puri,, Shahdara etc.: Parks, green tracks, broad roads should be made which could act as refuge zones.

Above issues should be taken into consideration and implemented in all mega cities of South Asia.

Earthquake Mitigation:

Earthquake mitigation includes structural and non-structural measures. Structural measures are those that strengthen the home and make it more resilient to earthquake damage. Non-structural measures include household preparedness or make the contents of the house less susceptible to damage. This also includes the purchase of earthquake insurance. In India, we have not focused so far on this issue.

Well-connected network of lifelines and communication:

Telecommunication networks are first to be affected by earthquake so it is very important to provide satellite telephones to the district collectors so that a link with the affected area can be made instantly in case of a disaster. Mobile hospitals should be installed in threat prone areas.

Securing underground urban facilities:

Underground urban facilities like shopping malls are vulnerable and require special attention.

Use of Solar and Wind Energy during Emergency:

On the pattern of Japanese Tsunami affected areas, Solar energy may be useful on the time of earthquake emergency.

Keeping Permanent Disaster Management Team equipped with suitable infrastructures for Mega Cities:

Infrastructures in form of trained personnel's, instruments to detect live humans who are buried beneath the debris of fallen buildings, trained dogs which can sniff living human beings under the debris.

Continuous Relay through Media about Do's and Don'ts:

Regular talks and advertisements on do's and don'ts during disaster situation should be a part of daily life. The information can be disseminated through radio, television and advertisements in cinema halls.

Earthquake Insurance:

On the pattern of developed countries like USA and Japan, Insurance is considered as important mitigation measures.

Political Leaders/VIPs should not visit the area within few days of earthquake:

They should not visit affected areas immediately after the disaster so that rescue and relief should not concentrate around VIPs only.

Curriculum Development and Role of Educational Institutions, Policy Makers and Community Leaders

- **Appropriate, Indigenous and solution-orientated** research for sustainability and survivability, to fulfill human needs for food, water, shelter, energy, health and livelihood.
- **Accessible effective interdisciplinary collaboration within the arena of human geosciences** with physical, natural and social sciences, humanities, geography, economics, and available technological development, to find the suitable scientific solutions to multi-faceted problems.
- **Available and timely information relating to disaster for decision/policy-makers** by generating the knowledge that will support existing and new global and regional integrated assessments for future needs.

- **Increased capacity building through participation of policy-makers, academicians, industrial establishment and other sectors of civil society** in science, technology and innovation, especially in developing countries and engagement of a new generation of scientists.
- **Teaching realistic ways of disaster preparedness** Students should be trained as relief personnel. It should be made compulsory for all students to learn the technique of preparation of first aid box. Involvement of NSS and NCC will be very effective.

Response of Present Nepal Earthquake: Concluding Remarks

It is necessary to co-ordinate the relief and aid packages amongst different countries. Cracks and damaged runway also hinder relief efforts at the Kathmandu airport. Armed forces, para-military, medicine, government and self-help groups should work in an integrated manner for response, rescue, resettlement and rehabilitation of disaster victims. Nepal has been shaken by around 70 aftershocks. Indian Government Response under leadership of Hon'ble PM Modi was quick and effective. Multi-dimensional livelihood framework can play an instrumental role for rehabilitation beyond rescue and relief. Each Himalayan thrust line like High Himalayan Crust Line sequence and India –Tsangpo Suture Zone should be dealt with consideration of Main Boundary Thrust, Main Central thrust and Sarchu Fault to study Himalayan micro vulnerability, mapping and monitoring. Earthquake Processes & Modeling (EPM) Analyses of data sets could greatly help in improving the understanding about the earthquake processes in the inter-plate and intra-plate seismic regimes structure in susceptible regions for further enhancing preparedness.