

Natural Hazards and Mitigation Measures With Special Reference to Arunachal Pradesh

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ABSTRACT: Natural Hazards are severe and extreme weather and climate events that occur naturally. These refer to all atmospheric, hydrologic, and geologic phenomena that have the potential to affect humans, their structures, or their activities adversely, because of their location, severity, and frequency. Natural Hazards can happen at any point of time, day or night, and thus, unexpected and unmanaged events. The various disasters include Earthquake, Landslide, Flood, Tsunami, Drought, Cyclone, Cloud Burst, Forest Fire, and many others.

Natural Hazards in Arunachal Pradesh include Earthquake, Landslide, Cloud Burst, Flash Flood and Forest Fire. Of these, Earthquakes, Landslides and Cloud Burst are the most destructive, in terms of loss of life and destruction of property and environmental degradation. Although these natural hazards cannot be stopped, however, the adverse affect of these calamities can be minimized. It is, thus, essential to understand the processes involved in occurrence of these phenomena, particularly in context of Arunachal Pradesh.

The geology of Arunachal Pradesh is very complex as it exhibits three different mountain systems of different origin in juxtaposition. These are : i) the Himalayan Ranges, ii) the Mishmi Hill Ranges, and iii) the Naga-Patkai-Arakan Ranges . **The Himalayan Ranges** in Arunachal forms a continuation of that in Darjeeling, Sikkim and Bhutan in its western part and continue up to the eastern part in Upper and East Siang districts and partly in Dibang Valley and Lohit districts. Geologically, the Himalayan Ranges in Arunachal Pradesh are divisible into three domain : Outer Himalaya, Lesser Himalaya and Higher Himalaya. As in other parts of the Eastern Himalaya, the Arunachal Himalaya also contains distinctive litho-tectonic units. **The Mishmi Hill Ranges**, which form a part of the Shan-Malaysia Plate, abut against the Himalayan Ranges along the Tuting-Tidding Suture Zone and are mostly present in the Dibang Valley and Lohit districts. These are represented by Mishmi Massif that abut against the Himalayan Ranges along a suture zone, named as the Tuting-Tidding Suture Zone. **The Naga-Patkai-Arakan Ranges** that abut against the Himalayan and Mishmi Hill ranges are present in Changlang and Tirap districts. These are represented by the Schuppen Belt of Upper Tertiary sequence.

The major litho-stratigraphic units of Arunachal Himalaya are thrust bound. Three major tectonic features of regional scale are present in Arunachal Himalaya, viz., Himalayan Frontal Fault (HFF), Main Boundary Thrust (MBT) and Main Central Thrust (MCT). Of these, MBT is a continuous tectonic datum between the Siwaliks and the pre-Tertiary sequences trending more or less in WSW-ENE direction; whereas MCT marks the datum between the Lesser and Higher Himalaya. Large-scale differential tectonic transport of the crystalline sheets have taken place along these thrust planes. The Mishmi Massif comprises predominantly of granodiorite and diorite bodies and granite plutons (Tuting Granite). The Tuting Granite is thrust over the metavolcanic of the Tuting -Tidding Belt along the Yang Sang Chu Thrust, which is considered to be a continuation of the Lohit Thrust. The Tertiary sequence of the Naga-Patkai-Arakan Terrane forms a part of the well-known Schuppen Belt, and is bounded by two major thrusts, viz., Disang Thrust and Naga Thrust. In addition, there are several transverse faults, which have truncated litho-tectonic units of the Lesser and Higher Himalaya.

It is a well known fact that Arunachal Pradesh falls under the high seismic zone, i.e. Zone V. It is because of its geographic position and geodynamically active three mountain systems, viz., the Himalayan ranges, the Mishmi hill ranges, and the Naga-Patkai-Arakan ranges. Movements in these mountains cause large number of earthquakes periodically along the thrust/faults planes, and quite a large part of the region is being affected by frequent landslides.

Various records show that earthquakes of different magnitude have been occurring frequently in Arunachal Pradesh. For example, a team of Wadia Institute of Himalayan Geology operated 10 seismic stations in different parts of Arunachal Pradesh for a period of 4-5 months in 1994. The study showed micro-seismic activity with a cluster of earthquakes of magnitudes 2 to 5 in West Kameng and Tawang districts, and another cluster with magnitudes ranging

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from 1 to 5 in the upper reaches of the Lohit Valley. Further, a linear zone of seismicity between magnitudes 2 to 4 occurs approximately along the MBT zone in foothill area. There are other institutions, such as North East Institute of Science & Technology (NEIST) formerly known as Regional Research Laboratory (RRL), National Geophysical Research Institute (NGRI), Manipur University, etc., which have been recording occurrence of earthquakes in the entire North-Eastern Region.

This shows that the seismic activity in Arunachal Himalaya is not uncommon and rather is a regular natural phenomenon, which however, cannot be predicted in terms of time, magnitude and place. On the other hand, unplanned developmental activities in Arunachal Pradesh, particularly the concrete construction for their modern life style, are increasing day by day without considering the vulnerability to the earthquakes.

The natural hazards, particularly the Earthquake and Landslide hazards, thus, need attention for comprehensive plan for preparedness and mitigation for sustainable reduction in disaster risk in hazard-prone areas through an integrated approach with active participation of the scientific community and society. Preparedness for Earthquake especially is very important particularly in metro cities having high density of life and property, where Earthquake can result in a large-scale disaster due to inappropriate structures.

The need of the day is to educate the general public regarding the danger from earthquake hazards and their mitigation. It is also important to follow strict enforcement of proper building codes. People themselves should realize to adopt the suitable building codes for their own safety. Keeping in view the vulnerability to the earthquake hazards, DOs and DON'Ts in case of an earthquake event have been suggested, which every one must follow for their personal protection.

Following studies are proposed and suitable actions are suggested :

- i. Set up of Seismic Observatories
- ii. Preparation of Hazards Zonation Maps (1:50,000 scale)
 - a. Sub-Seismic Zonation Maps,
 - b. Landslide Hazards Zonation Maps, and
 - c. Lineament Maps with demarcation of active faults.
- iii. Study of Historical Earthquakes (Palaeoseismicity)
- iv. Landslides Studies
 - a. Preparing database of old, active and inactive landslides;
 - b. Preparation of Landslides Hazards Zonation Maps;
 - c. Monitoring of active landslides and high risk areas; and
 - d. To suggest remedial measures.
- v. Set up Global Positioning System (GPS) Stations
- vi. Creation of Public Awareness
- vii. Education in Hazards Mitigation
- viii. Training Programs and Workshops
- ix. Law Enforcement

I. INTRODUCTION

Natural Hazards are severe and extreme weather and climate events that occur naturally. These refer to all atmospheric, hydrologic, and geologic phenomena that have the potential to affect humans, their structures, or their activities adversely, because of their location, severity, and frequency. Natural Hazards can happen at any point of time, day or night, and thus, unexpected and unmanaged events. The various natural hazards include Earthquake, Landslide, Flood, Tsunami, Drought, Cyclone, Cloud Burst, Forest Fire, and many others.

The Indian subcontinent is highly vulnerable to such natural hazards because of the unique geo-climatic conditions of this subcontinent. The figures related to Hazard Vulnerability in India show that :

- 57 % of land is vulnerable to Earthquakes
- 28 % of land is vulnerable to Drought
- 12 % of land is vulnerable to Floods
- 8 % of land is vulnerable to Cyclones

Among all the States and Union Territories of the country, 25 are more disaster prone, and Arunachal is one of these States. Most common natural hazards in Arunachal Pradesh are Earthquake, Landslide, Cloud Burst, and Flash Flood.

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Forest Fire is another hazard that is common in the State. Of these, Earthquakes, Landslides and Cloud Burst are the most destructive, in terms of loss of life and destruction of property and environmental degradation. Although these natural hazards cannot be stopped, however, the adverse affect of these calamities can be minimized. It is, thus, essential to understand the processes involved in occurrence of these phenomena, particularly in context of Arunachal Pradesh.

II. GEOLOGICAL SET UP OF ARUNACHAL PRADESH

The geology of Arunachal Pradesh is very complex as it exhibits three different mountain systems of different origin in juxtaposition. These are : i) the Himalayan Ranges, ii) the Mishmi Hill Ranges, and iii) the Naga-Patkai-Arakan Ranges. **The Himalayan Ranges** in Arunachal forms a continuation of that in Darjeeling, Sikkim and Bhutan in its western part and continue up to the eastern part in Upper and East Siang districts and partly in Dibang Valley and Lohit districts. Geologically, the Himalayan Ranges in Arunachal Pradesh are divisible into three domain : Outer Himalaya, Lesser Himalaya and Higher Himalaya. As in other parts of the Eastern Himalaya, the Arunachal Himalaya also contains distinctive litho-tectonic units. **The Mishmi Hill Ranges**, which form a part of the Shan-Malaysia Plate, abut against the Himalayan Ranges along the Tuting-Tidding Suture Zone and are mostly present in the Dibang Valley and Lohit districts. These are represented by Mishmi Massif that abut against the Himalayan Ranges along a suture zone, named as the Tuting-Tidding Suture Zone. **The Naga-Patkai-Arakan Ranges** that abut against the Himalayan and Mishmi Hill ranges are present in Changlang and Tirap districts. These are represented by the Schuppean Belt of Upper Tertiary sequence.

It is a well known fact that Arunachal Pradesh falls under the high seismic zone, i.e. Zone V. It is because of its geographic position and geodynamically active above mentioned three mountain systems, viz., the Himalayan ranges, the Mishmi hill ranges, and the Naga-Patkai-Arakan ranges. Movements in these mountains cause large number of earthquakes periodically along the thrust/faults planes, and quite a large part of the region is being affected by frequent landslides.

III. PREPAREDNESS STRATEGIES

It has been observed that there are particular regions, which are periodically exposed to the same hazards, but many a times other hazards are striking the regions where they are not expected. For example, on the one hand, earthquake can occur anytime anywhere, on the other hand, floods and cyclones occur at certain places annually. Therefore, communities that periodically face the wrath of the nature have to be helped to cope up with these disasters and prepare well in advance so that losses are minimized. At the same time, it is also important to know how to act in any emergency situation to avoid accidents arising from panic and ignorance. In nut shell, disaster preparedness and mitigation measures have to be applied almost universally.

The natural hazards, thus, need attention for comprehensive plan for hazards assessment, preparedness and mitigation for sustainable reduction in disaster risk in hazard-prone areas through an integrated approach with active participation of the scientific community and society.

An effective strategy for disaster mitigation may be divided into the following related activities :

i) Advance Planning : It is most important activity aimed at providing basic directions for creating an environment for long-term protection. It involves :

- Identification of hazard-prone regions on the basis of historical and current knowledge as well as conceptual anticipation.
- Design of engineering specifications for various kind of structure, particularly construction of more than two storey buildings in urban agglomeration.
- Assessment of the vulnerability and risk faced by existing structure and design for retrofitting, wherever necessary. Special attention may be given to all essential buildings, such as hospitals, schools and colleges, telephone exchanges, power houses, water supply, etc.
- Design & operational readiness of protocols for effective rescue and relief measures, prevention of epidemics, and emergency operation of critical services.
- Regular dissemination of information through carefully designed bulletins to evoke a constructive response and avoid panic.

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ii) Rehabilitation and Resettlement : It is a consequential aspect to be taken up on priority basis to provide living atmosphere to the affected people in which they use to live before the calamity. This includes land & building, monetary package, livestock, other economic assets, etc. It is, thus, important to prepare alternate plans for rehabilitation and Resettlement in case of natural hazard. It is essential to regain social life, status and self-confidence of the affected people. It is not an easy task, because many people have sentimental attachments to their parental belongings and socio-cultural relations.

iii) Research and Development : This strategy aims at meticulous scientific preparedness through development of low cost and locally supportable technologies. Efforts should be made for improvement of slope stability, landform classification, etc., and further research be taken up in estimating and mapping the hazards intensities in the threatened areas. Therefore, Scientists, Technologists, Engineers and Administration have a role to play in providing safe, appropriate and economical solutions.

a) Scientists Domain - relates to quantification of hazards through improved understanding of hazards occurrence.

b) Technologists & Engineers Domain - relates to choice of appropriate analytical models for developing safe and economic designs.

c) Administration Domain - relates to public awareness and preparedness programs, particularly rehabilitation and restoring their normal activity.

iv) Awareness Creation : The need of the day is to educate the general public regarding the danger from the natural hazards and their mitigation. Most important is to follow strict enforcement of proper building codes. People themselves should realize to adopt the suitable building codes for their own safety.

A very important aspect for hazards analysis and disaster mitigation is availability of instruments and trained man-power, and support from media for public awareness.

In case of earthquake hazards, there are varied opinions regarding occurrence of next great earthquake in the North-Eastern Region. This has created panic in the public, especially when the media propagates future occurrence of earthquake based on prediction by some scientist. Though highly scientific and theoretical seismological studies could make prediction for space (where ?), but never about time (when ?). So we should not look for the prediction, but prepare ourselves from the earthquake events.

Further, towards extension of the knowledge for better understanding of the natural hazard mitigation and management, it is desirable to have a meaningful interaction between the *scientists and technical experts*, on one hand, and *administrators and planners*, on the other hand, on regular basis. It is possible through State and National level workshops and training programs, which may not only produce trained man-power but also result into meaningful recommendations for implementation by the State Government.

The natural hazards, particularly the Earthquake and Landslide hazards, need attention for comprehensive plan for preparedness and mitigation for sustainable reduction in disaster risk in hazard-prone areas through an integrated approach with active participation of the scientific community and society. Preparedness for Earthquake especially is very important particularly in district headquarters having high density of life and property, where Earthquake can result in a large-scale disaster due to inappropriate structures.

IV. ACTIONS SUGGESTED

Arunachal Pradesh falls under high seismic zone, and thus, natural hazards mitigation, particularly Earthquake and Landslide Hazards mitigation, needs utmost attention to ensure sustainable development in the State. While it is not possible to prevent natural disasters from occurring, however, the impact of these disasters may be reduced and loss of life and properties may be minimized by adopting suitable mitigation measures. It is said that "Prevention is better than Cure". Therefore, prevention approach should be taken rather than the curative approach in Hazard Reduction Policy. It is desirable to adopt an integrated approach from anticipation to preparedness, relief, rehabilitation and recovery. It is well said that "Hazards, both - natural and man-made, are inevitable but every hazard need not convert into a Disaster !"

There is a requirement of carrying out the mapping of cities and rural areas for vulnerability assessment, which may suggest the areas suitable for development activities or vulnerable to the disasters. A classic example is observed in Lower Dibang Valley District, Arunachal Pradesh, where a bridge over Deopani River near Roing has been collapsed

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as it was situated near the Himalayan Frontal Fault, which is considered to be active. Similarly, Hunli – a sub-divisional headquarter, has been established on the old landslide debris in Lower Dibang Valley District, which has been reactivated making the area vulnerable.

Efforts may be made towards meticulous scientific preparedness through development of low cost and locally supportable technologies for improvement of slope stability, landform classification, etc. Further, research be taken up in estimating and mapping the hazards intensities in the threatened areas.

In this context, following studies are proposed and suitable actions are suggested :

- x. Set up of Seismic Observatories
- xi. Preparation of Hazards Zonation Maps (1:50,000 scale)
 - a. Sub-Seismic Zonation Maps,
 - b. Landslide Hazards Zonation Maps, and
 - c. Lineament Maps with demarcation of active faults.
- xii. Study of Historical Earthquakes (Palaeo-seismicity)
- xiii. Landslides Studies
 - a. Preparing database of old, active and inactive landslides;
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 - c. Monitoring of active landslides and high risk areas; and
 - d. To suggest remedial measures.
- xiv. Set up Global Positioning System (GPS) Stations
- xv. Creation of Public Awareness
- xvi. Education in Hazards Mitigation
- xvii. Training Programs and Workshops
- xviii. Law Enforcement and Enforcement of Building Codes and Bye-laws

Although certain standards have been laid down for construction of earthquake resistant buildings in the seismic zones, more often than not it is observed that these codes and standards are not followed religiously. Example may be taken of Itanagar Capital Complex, where multi-storey buildings are coming up without considering the bearing capacity of the soil. Even multi-storey buildings have been constructed over the drains without considering the catchment area of that particular drain. Enforcement of Building Codes and By-laws will certainly go a long way in ensuring safety and longevity of the people and civil construction.

Even the financial institutions providing loan for construction purposes have to be sensitized to the need for making their investment secure by insisting on earthquake resistant construction by the loanee, where necessary mandatory insurance of all buildings above a stipulated value, size or category, both public and private, have to be ensured through suitable legislation.

Valdiya (2002) has already suggested to constitute a State Commission, which could be called the *Arunachal Pradesh Natural Hazards Management Commission (APNHMC)*, to provide the community with all information relating to the vulnerability of areas to hazards, extent and magnitude of risks and likely impacts, and the mitigation measures to be taken up in time.

There is an urgent requirement of sensitizing all stake holders to make them aware of their risks and vulnerabilities and seeking their support and co-operation for making a Disaster Management Plan through structural and non structural means. It is important because a large number of developmental activities in terms of hydro electric power projects, development of infrastructure, etc. are also under progress in Arunachal Pradesh. A holistic view has to be taken of all the developmental activities and urbanization pattern due to location of the State in High Seismic Zone.

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