



Received: 23-02-2022

Accepted: 03-04-2022

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Environmental Hazards in Arunachal Pradesh

¹ Shiva Nand Jha

¹ Principal, Jawaharlal Nehru College, Arunachal Pradesh, India

Corresponding Author: Shiva Nand Jha

Abstract

Environmental hazards are associated with the severe or extreme physiographic, geologic and climatic events that occur naturally or coupled with human induced causes. These refer to all atmospheric, hydrologic, and geologic phenomena that have the potential to affect humans, their structures, their activities and overall environment adversely.

The Indian subcontinent is highly vulnerable to natural hazards. The figures related to hazard vulnerability in India show that about 57 % of land is vulnerable to earthquakes, 28 % of land is vulnerable to drought, 12.7% of land mass falls under the landslide-prone hazardous zone, 12 % of land is vulnerable to floods, and 8 % of land is vulnerable to Cyclones.

Earthquake, Landslide, Cloud Burst, and Flash flood are the common hazards in Arunachal Pradesh. Forest Fire is another hazard that is common in the State. Being a part of mountainous Himalayan territory, all these hazards become

more destructive in Arunachal Pradesh. It is, thus, essential to understand the status, causes, level of severity and conservation/mitigation measures related to these hazards in context of Arunachal Pradesh.

The present paper seeks to examine the three important environmental hazards- Earthquake, Deforestation, and Landslides in context of Arunachal Pradesh. The unique geological set-up and the geo-environmental make-up of the state have been assessed as the background of the study.

There is an urgent need of sensitizing all stake holders to make them aware of risks and vulnerabilities about these hazards. A large number of developmental activities, e.g., hydroelectric power projects, development of infrastructure, etc. are under progress in Arunachal Pradesh. A holistic view has to be taken of all the developmental activities, considering the location of the State in High Seismic Zone and highly fragile ecosystem.

Keywords: Hazard, Vulnerability, Mitigation, Geological Set-up

Introduction

Environmental Hazards are associated with the severe or extreme physiographic, geologic and climatic events that occur naturally or also coupled with human induced causes. These refer to all atmospheric, hydrologic, and geologic phenomena that have the potential to affect humans, their structures, their activities and overall environment adversely. Hazards can happen at any point of time, 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 natural hazards because of the unique geo-climatic conditions of this subcontinent. The figures related to Hazard Vulnerability in India show that:

About 57 % of land is vulnerable to earthquakes

About 28 % of land is vulnerable to Drought

About 12.7% of land mass falls under the landslide-prone hazardous zone.

About 12 % of land is vulnerable to Floods

About 8 % of land is vulnerable to Cyclones

Among all the 36 States and Union Territories of the country, 27 are disaster prone, and Arunachal is one of these states. Most common environmental hazards in Arunachal Pradesh are Deforestation, Earthquake, Landslide, Cloud Burst, and Flash flood. Forest Fire is another hazard that is common in the State. All these hazards are common and become more destructive with the simple reason that the state of Arunachal Pradesh is a mountainous Himalayan territory. These hazards cause loss of lives, destruction of property and environmental degradation. It is, thus, essential to understand the status, causes, level of severity

and conservation/mitigation measures related to these hazards in context of Arunachal Pradesh.

The important environmental hazards in Arunachal Pradesh, e.g., Earthquake, Deforestation, and Landslides are discussed here. However, Flood and Cloud burst hazards are also immensely significant in context of Arunachal Pradesh

Earthquake hazard

Arunachal Pradesh falls under the highly vulnerable seismic zone, i.e., Zone V. It is because of its geographic position and complex geology. The location and the geology of the state act as the causative factors of earthquake. The geology of Arunachal Pradesh exhibits three different mountain systems of different origin in juxtaposition. These are:

1. The Himalayan Ranges,

- 2. The Mishmi Hill Ranges, and
- 3. 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 domains: Outer Himalaya, Lesser Himalaya and the Greater Himalaya. As in other parts of the Eastern Himalaya, the Arunachal Himalaya also contains distinctive litho-tectonic units. (Physiographic and geological characteristics of Arunachal Pradesh are evident from fig 1 and fig 2)

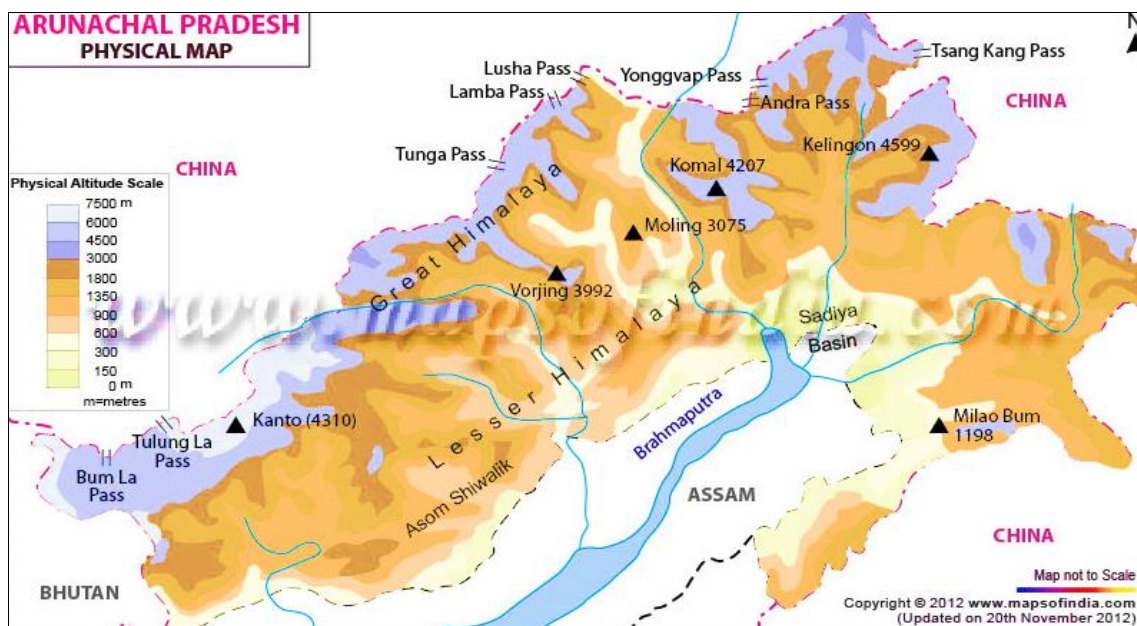


Fig. 1: Physiography of Arunachal Pradesh

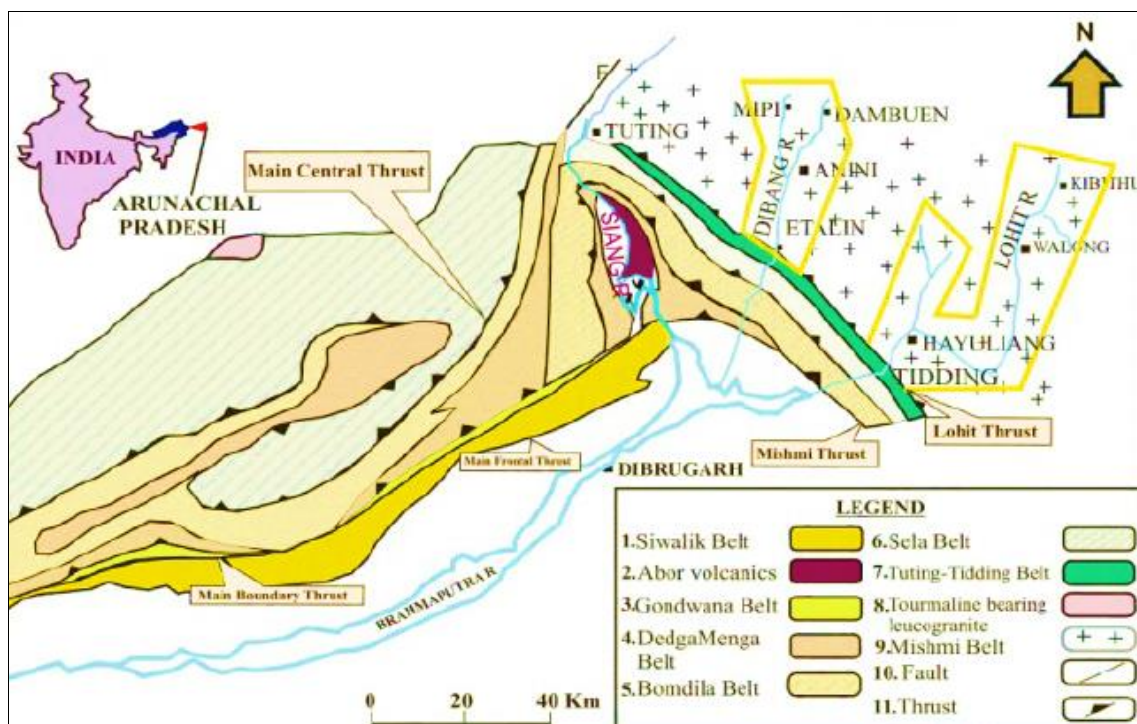


Fig 2: Geological Map of Arunachal Pradesh (modified by Singh & Choudhury)

The Mishmi Hill Ranges, which form a part of the Shan-Malaysia Plate, adjoin 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 adjoin against the Himalayan Ranges along a suture zone, named as the Tuting-Tidding Suture Zone.

The Naga-Patkai-Arakan Ranges that adjoin 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.

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 has taken place along these thrust planes. Besides, there are several transverse faults, which have truncated litho-tectonic units of the Lesser and Higher Himalaya.

Movements in the above-mentioned mountain systems, viz., the Himalayan ranges, the Mishmi hill ranges, and the Naga-Patkai-Arakan ranges cause large number of earthquakes periodically along the thrust/faults planes. Various records

show that earthquakes of different magnitude have been occurring frequently in Arunachal Pradesh.

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 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 Main Boundary Thrust (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. Major earthquakes and seismic epicentres of Arunachal Pradesh are evident from table 1 and fig 3.

Table 1: Major Earthquakes in Arunachal Pradesh

Year	Magnitude in Richter Scale
1906	7.0
1908	7.5
1941	6.8
1947	7.7
1950	8.7

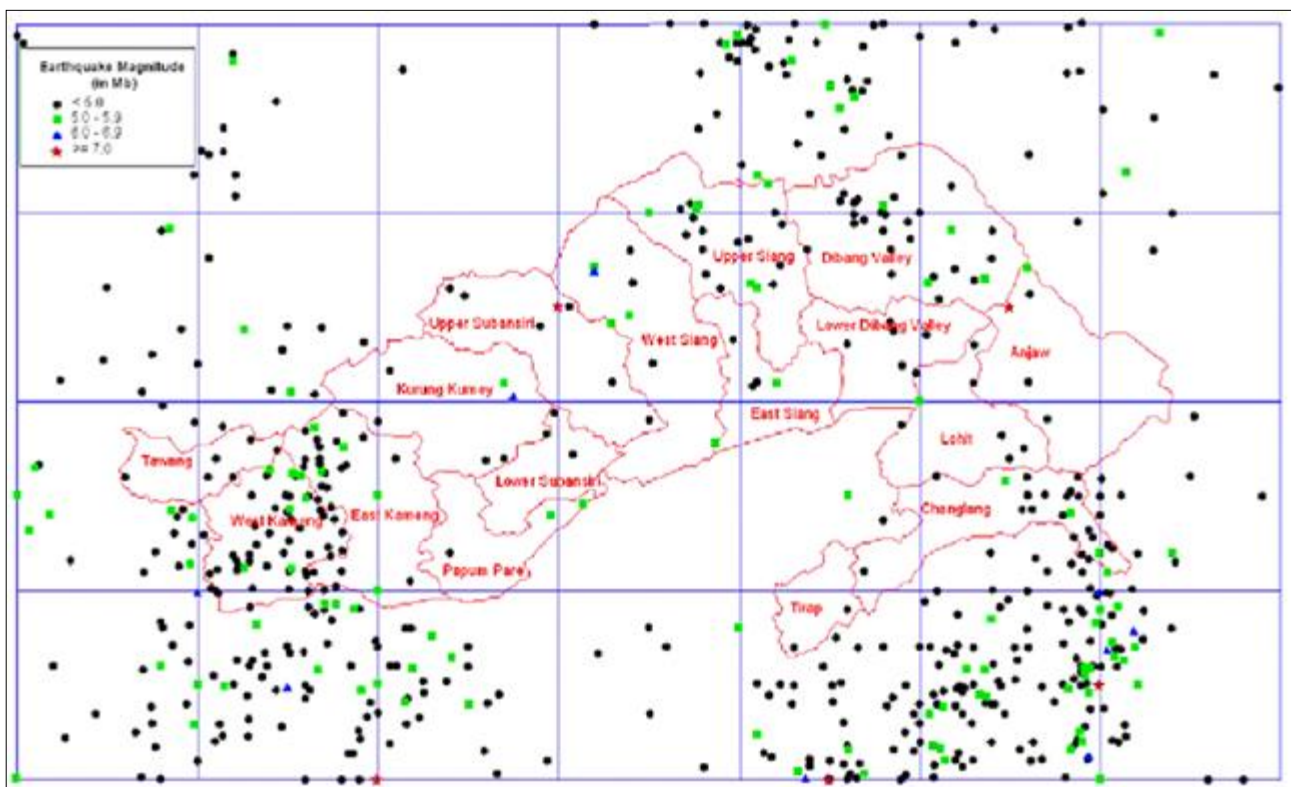


Fig 3: Seismic epicentres map of Arunachal Pradesh and surrounding region (data period 1906 to 2003)

It is evident from the above-mentioned facts that seismic activity in Arunachal Himalaya 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 state, particularly the concrete construction are increasing day by day without considering the vulnerability to the earthquakes.

Preparedness strategies

Earthquake can occur anytime anywhere. 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. An effective strategy for disaster

mitigation may be divided into the following related activities:

1. **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, educational institutions, power houses, etc.
 - Design and 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.
2. **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. It is essential to regain social life, status and self-confidence of the affected people.
3. **Research and development:** This strategy aims at meticulous scientific preparedness through development of low cost and locally supportable technologies. Scientists, Technologists, Engineers and Administration have a role to play in providing safe, appropriate and economical solutions.
4. **Awareness creation:** It is immensely important to educate the general public regarding the danger from the earthquake 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. Availability of essential instruments and trained manpower, and support from media for public awareness are also very important.

Misconception about Earthquake: there are misconceptions 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 so-called scientist. Though highly scientific and theoretical seismological studies could make prediction for space (where?), but never about time (when?). So, we must avoid and ignore such prediction, but prepare ourselves from the earthquake events.

Suggested measures

Arunachal Pradesh falls under high seismic zone, and thus, earthquake hazards mitigation needs utmost attention. While it is not possible to prevent earthquakes from occurring but the impact of these earthquakes may be reduced and loss of life and properties may be minimized by adopting suitable

mitigation measures.

There is a requirement of carrying out the mapping of towns and rural areas for vulnerability assessment, which may suggest the areas suitable for development activities or vulnerable to the disasters. An example observed in Lower Dibang Valley District, where a bridge over Deopani River near Roing collapsed as it was situated near the Himalayan Frontal Fault, which is considered to be active. Similarly, Hunli – a sub-divisional headquarter in Lower Dibang Valley District, has been established on the old landslide debris, 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. Keeping in view the vulnerability to the earthquake hazards, DOs and DON'Ts in case of an earthquake event have been suggested, which everyone must follow for their personal protection.

In this context, following studies and suitable actions may be proposed:

1. Set up of Seismic Observatories
2. Preparation of Hazards Zonation Maps
 - a) Sub-Seismic Zonation Maps,
 - b) Lineament Maps with demarcation of active faults.
3. Study of Historical Earthquakes (Palaeo-seismicity)
4. Set up Global Positioning System (GPS) Stations
5. Creation of Public Awareness
6. Education in Hazards Mitigation
7. Training Programs and Workshops
8. 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, it is not followed strictly. 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.

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 hydroelectric 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 in view of the location of the State in High Seismic Zone.

Deforestation in Arunachal Pradesh

As per the Forest Survey of India Report 2019, India has a forest cover of almost 25 percent of total area. However, the

report highlights that Northeast India continues to lose forests when compared to previous reports, witnessing a loss of about 3,199 sq. km of forests since 2009. Arunachal Pradesh in north-east India is the richest terrestrial biodiversity region in India.

Arunachal Pradesh has the second largest forest cover in the country with 66,687 sq. (79.63 percent of the state's geographical area) and has the highest percentage of highly dense forest of nearly 21 thousand sq. km. The State is also one of the world's 18 biodiversity hotspots with about 20 percent species of the country's fauna, nearly 6000 flowering plants and half of the bird species known from India. The state also possesses more than 500 species of orchids. Recent research has led to the discovery of new records, range extensions and new species of plants and animals from the state. In terms of legal status, 11.37 % of the geographical area of the state is under the Protected Area network (Wildlife Sanctuaries and National Parks, Tiger Reserves etc.). 37% of area under Unclassed State Forest, and 11.61% under Reserved Forests. The state is indeed blessed with tremendous natural resources with vast potential for forest and agro-based model of economy.

Deforestation and its responsible causes

The latest alarming report (2019) is that the forest cover in the state has decreased by 276.22 sq. km as compared to the previous assessment reported in 2017. Further, the FSI reports estimate that 486 sq. km of forest was lost from 2003 to 2017 in Arunachal Pradesh (FSI 2003, 2005, 2009, 2011, 2013, 2017).

Reduction in forest cover is caused by a variety of reasons, including *jhum* (shifting) cultivation, timber business, conversion of forested areas for construction of houses, offices and irrigation fields, hill-cutting to create roads, real estate, firewood, and other developmental activities.

With 80% of the population practicing subsistence farming in the hilly terrain, people were primarily dependent on shifting cultivation which is mainly carried out in the USF or community forests. Shifting cultivation was estimated to cover 2040 sq. km in 2008-09 (Wasteland Atlas 2011) but is now in decline among many communities. Although shifting cultivation is usually cited as the main cause of forest loss in the state, but there are several causes of forest loss such as: agricultural expansion, growth of plantation crops such as oil palm, rubber, tea, opium, illegal logging and road expansion etc. The increasing need of land for various purposes due to rapidly growing population is quite natural. As a matter of fact, in a forested state like Arunachal Pradesh, wherever developmental activities will take place, they are bound to happen at the cost of forest loss. Lack of land demarcation and cadastral surveys are other reasons for deforestation.

Indigenous People, Forest and Forest Conservation

The tribal or indigenous people of Arunachal Pradesh have an inextricable relation with the forest. The forest holds a central position in every tribe's socio-economic and cultural matrix of life. It is believed that nobody knows and understands the forest better than the village elders. Every aspect of society whether it is basic requirements and cultural ethos are somewhat connected to forest. It is the lifeline of the society. Other than the Government owned reserve forest, protected forest, wild life sanctuaries, national parks everything else such as land, forest, rivers,

trees etc. have owners as an individual, family, clan or community which is customarily recognized. Customary laws become the main source of law in the social fabric of Arunachal Pradesh. The customary laws governed by traditional institutions have a major role to play in forest matters at the village level. The dynamics of customary laws pertaining to forest needs to be well understood by the policy makers.

Considering the pivotal role of local communities, the Draft Arunachal Pradesh Forest Act 2014 prepared by the Department of Forest has immense relevance to the people and State of Arunachal Pradesh. It may be easily regarded as one of the most crucial legislations to be enacted so far. A comprehensive law on forest is much desirable in order to have a holistic approach to all the problems associated with forest ranging from conservation, regulation to sustainable management of forest resources and livelihood issues with an inward-looking policy rather than outward.

According to tribal beliefs in Arunachal Pradesh, dense forests and big trees are looked upon as ancestral souls, and hornbill hunting is banned during the breeding season. The tiger is sacred as it is the 'brother of Tani, the first humans on earth'. Arunachal Pradesh is attempting to show that community ownership can help produce incomes from biodiversity sustainably. There is strong support for conservation of fauna too.

The Nature Conservation Foundation has been working in the area around the Pakke Tiger Reserve with the Nyishi tribal people, successfully persuading them against hunting of hornbills. Tribal residents have participated in nest protection schemes, and local councils have seized guns from villages. An adoption scheme launched by NCF for the hornbills has attracted 49 urban patrons, who paid between Rs. 1,000 and Rs. 1 lakh to protect the birds in nesting sites. Although cutting of trees and timber business was banned by the Supreme Court way back in 1996, it appears that tree cutting and logging have increased unabated in the past few years. Rampant deforestation is leading to massive river erosion, global warming, extreme weather, flooding, loss of flora and fauna, etc.

One of the major causes of deforestation is widespread cutting of trees for firewood. The government and social organizations should take a lead role in promoting adoption of alternative sources like LPG, biogas and solar plants in our villages and towns for cooking and heating requirements, which would reduce the cutting of trees for firewood.

The government and social organizations should also take a lead role in planting more trees. This may be promoted through horticulture or other plantation crops like tea, rubber, oil palm, orange, etc. Illegal timber business should be banned and concerned laws strictly implemented.

In addition, Joint Forest Management (JFM), Remuneration and recognition of afforestation activities, proper forest and environmental education to new generation and age-old tradition of man-nature interdependence relationships can go a long way in restricting the problem of deforestation.

One area that has substantial potential is bamboo. There are a number of bamboo species that grow in Arunachal Pradesh. Bamboo resource can be used in a variety of application to generate livelihood in the state.

Resource mapping must constitute an integral part of the forest conservation strategy with a view to identifying endemic species, and threats to biological diversity. This can

help to evolve a protected area management plan.

Landslide hazard

When rocks are disintegrated and decomposed by the process of weathering, weathered material soaked with rain water may slide down due to gravity. Such a sudden downward slip movement of rock debris is called landslide. Occurrence of landslides is particularly common in geodynamic sensitive belts i.e., zones and areas repeatedly rocked by earthquakes and affected by other geo-tectonic activities.

The mountainous location with complex physiography, climate, geology, soil and other associated natural and human induced factors have contributed to make Arunachal Pradesh a landslide prone territory. 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/fault's planes, and quite a large part of the region is being affected by frequent landslides.

Landslides: Causes and effects

The significant factors that trigger landslides in Arunachal include:

1. **Heavy and prolonged rainfall.** The amount of rainfall is more than 200 cm/yr.
2. **Cutting on slope** for construction of building, roads, and other developmental activities. Landslides occur in most of the areas of state, where the terrain is altered for construction works.
3. **Earthquake shocks and tremors.** Since the factors affecting occurrence of landslides can be geophysical or manmade, they may occur in developed or undeveloped areas. The Himalaya is seismically the most active segment of the Indian sub-continent. its north-eastern part, where Arunachal lies, are repeatedly rocked by earthquakes of considerable magnitudes
4. Wide spread deforestation for development activities and increasing population pressure has forced people to move up the steeper forested slopes with their ploughs and livestock's, which further aggravates occurrence of landslides.

As a geomorphic hazard, landslide and its related phenomena such as mudflows, earth flows, rock falls, debris avalanches and subsidence are natural as well as anthropogenic. Loss of life and property from landslides in the hilly terrain are substantial, especially in the geologically unstable Himalayan terrain. Arunachal Pradesh represents such fragile terrain and therefore, are very much susceptible to landslides and their devastating consequences. Landslide is a recurring phenomenon in Arunachal Himalayan region due to its rugged topography. Due to lack of plain area, the

increasing population pressure is leading to settlement expansion along with agricultural activities on the steep sided slopes mostly along the road highways through earth cutting on the hill top and slopes. Such activities have reduced the strength of the regolith cover and has contributed to make the slopes more susceptible to slope failure. Abundant supply of loose sediment due to slope cutting frequently resulted in mud slide, debris flow, etc. during rainy season. High intensity of rains for long duration causes soil and rock debris to move down slope that cause frequent road blockage and disturb traffic movement.

Tage Rupa in her study on Landslide for the area- 'The National Highway No. 52A connecting the twin capital Naharlagun and Itanagar' observed that large scale of landslide which is occurring frequently during monsoon season are due to the existence of very dense drainage network system, supported by very high rainfall, especially concentrated during SW monsoon, i.e., rainy season (65%). Such conditions are responsible for the weakening of rock mass and large-scale erosional activities and toe cutting of the valley slopes. Besides, the unplanned growth of settlements on hill faces, cutting and levelling of hill slopes, degradation of natural drainage system, cutting and felling of trees, especially along hill faces and increased run off due to increase in impervious areas are the main issues and challenges that has triggered more landslide in the study area.

The Highway which runs only 34.5Km connecting Banderdewa – Nirjuli – Naharlagun – Itanagar – Chimpu – Gohpur plays lifeline for the people residing in these localities. During recent years, Capital Complex area has grown very fast with linearly growth along the NH 52A. Pressures of urban expansion on ecologically fragile hill slopes have accelerated the effect of landslide hazard. The undercutting of the river on the concave ridges often causes the road to overhang which ultimately leads to collapse.

There were eight major landslide zones, viz. Karsingsa landslide (some 8 Km away from the plains of Assam), Nirjuli landslide, Lekhi landslide, Naharlagun landslide, Barapani landslide, Pahalwan Mod landslide and Gohpur road landslide. Besides these landslides, there are large number of minor slides in the form of road cave in different locations which becomes menace for the people during rainy days. These all landslides, resulting subsidence and sinking of road, and blockage of road through accumulation of huge amount of debris. During the 2008 landslide, all the entry points from northern Assam to the NH 52A to the state of Arunachal Pradesh was blocked. The main block point was at Karsingsa where there was hardly any kilometre of road left without landslide.

During rainy seasons, if such a small mountainous stretch of about 30 km is so severely affected by landslides, one can simply imagine the picture of whole of the Arunachal Pradesh.



Photo credit: Manogya Loiwal

Fig 4 and 5: Photographic Image of Landslides in Lower Siang area

Suggestions

Prevention of landslide is difficult, but proper planning and good engineering practice can do much to minimize the hazard. Common engineering techniques for landslide prevention include provisions for surface and subsurface drainage, removal of unstable slope materials (grading) and construction of retaining walls wherever possible. Restriction on felling of trees and earth cutting on the hill slopes and awareness to promote plantation on the slopes through social forestry and conservation of soils are some of the preventive measures. In addition, haphazard building constructions without expert consultation and soil testing and public awareness is needed regarding the soil type, geomorphic process and its associated hazards. It's high time for Arunachalee people to follow the Wildlife Protection Act as well as the Environmental Protection Act in the best interest of forest ecology restoration. The natural hazards, particularly the 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.

Landslide safety tips

- Avoid building houses near steep slopes, close to mountain edges, near drainage ways or along natural erosion valleys. Avoid going to places affected by debris flow.
- Stay alert and awake. Many deaths from landslides occur while people are sleeping. Listen for unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together.
- Move away from the landslide path or debris flow as quickly as possible.
- Avoid river valleys and low-lying areas. If you are near a stream or channel, be alert for any sudden increase or decrease in water flow and notice whether the water changes from clear to muddy.
- Go to designated public shelter if you have been told to evacuate.
- Stay away from the slide area as there may be danger of additional slides.
- Check for injured and trapped persons near the slide, without entering the direct slide area.

Concluding remark

The pursuit of sustainability demands a critical shift in

human's perception from an industrial man to an eco-friendly person. There is also a need to take advantage of the 'traditional ecological knowledge' (TEK), which encompasses all issues linked to ecology, sustainability, hazard natural resource and environmental management, both at local and regional levels.

References

1. Jha SN. Disaster Management: The Indian Context, Shree Navman Publications, Aligarh, 2021, 1-10.
2. Singh T. Natural Hazards and Mitigation Measures with Special Reference to Arunachal Pradesh, IJRSET. 2016; 5(SI6):8-12.
3. Singh RB. Natural Hazards & Disaster Management, Vulnerability and Mitigation, Rawat Publications, Jaipur, 2012, 3-4.
4. State Disaster Management Plan, Arunachal Pradesh, Itanagar, 2019.
5. Valdiya KS. Geodynamic perspective of Arunachal Pradesh: bearing on environmental security and planning for development. in R.C. Sundriyal, Trilochan Singh, and G.N. Sinha (Eds.), Arunachal Pradesh: Environmental Planning and Sustainable Development. HIMAVIKAS Occasional Publication. 2002; 16:1-15.