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Geographical Perspective of Geomorphological Hazards in Kohima District of Nagaland

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ABSTRACT

Kohima, located in northeastern India, is a geologically unstable area with incessant rainfall during pre-monsoon and inter-monsoon periods, making it very prone to geomorphological hazards such as landslides and flash floods. Every year, the region is faced with massive inconvenience due to the high intensity of rainfall, which contributes to the displacement of the already unstable lithology of the district and thus leads to the blockade of roads, damages to houses and properties, loss of vegetative cover, and blocking of rivers and streams by falling debris due to landslides along the rivers. In addition to the natural factors of lithology and climate, the most encroaching anthropogenic activity of road construction has further intensified the situation due to more felling of trees, removal of earth materials and dumping of the removed earth materials on the land itself, resulting in added pressure and thus sinking of land persists.

Keywords : Geomorphological Hazards, Landslides, Monsoon Rainfall

I. INTRODUCTION

Natural hazards are usually taken within the realm of hydro-meteorological and geological concepts, such as landslides, earthquakes, floods, tsunamis, etc., most of which are geomorphological in nature due to their essential ingredient of being the result of the earth's surface dynamic. Geomorphic hazards can be regarded as threats to human resources resulting from the instability of the earth's surface features (Gares et al., 1994). In reality, the identification of geomorphic hazards is based on the prediction of landform change (Chorley et al., 1984). Hazards of geomorphic origin are permanently attached to the two geomorphic activities of landforms- endogenic activity and exogenic activity. Endogenic activities are landform processing activities that operate from within the earth's surface, such as seismic and volcanic activities and give rise to new landforms, which also serve as the platform for exogenic activities. Exogenic activities, on the other hand, relates to those activities such as floods, karst collapse, snow avalanche, channel erosion, sedimentation, mass movement, tsunamis, coastal erosion and those induced by climate and land-use change such as desertification, permafrost, degradation, soil erosion, salinisation, floods. (Slaymaker, 1996). Between the 2 geomorphic activities, man can only alter the exogenic activities in terms of escalating their frequency or increasing their intensity, such as storms, floods, fire, landslides etc., by human interferences in the form of infrastructure development, climate change, land use and other human-related activities which may have little or more effect on the environment. These hazards are considered threats and become a disaster when it significantly impacts society and the infrastructures and produces damage not only at the moment of this occurrence but also on a long-term basis due to their associated consequences (Ayala, 2002). In reality, the identification of geomorphic hazards is based on the prediction of landform change (Chorley et al., 1984). The study of geomorphological hazards involves risk identification, risk assessment, determination of risk magnitude, risk responses and takers, risk acceptability, risk avoidance, risk mitigation etc. (Savindra Singh, 2018).

Kohima- The study area:

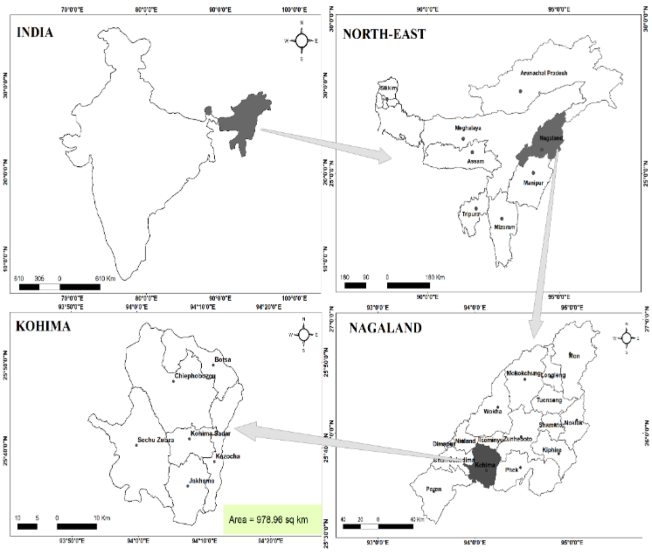

Figure 1: Study area map viz., Kohima district of Nagaland

The highest geomorphic activity or hazard in Kohima is mainly driven by monsoonal precipitation. The district receives heavy rainfall of an average of 2500mm annually. In addition to that, Kohima is almost entirely a hilly and undulating terrain with an average elevation of 1444 m.a.s.l. It covers an area of 978.96 sq. km. It is the state capital of Nagaland in North-east India, considered one of the most geomorphologically unstable regions in the country and the world. Kohima lies on an unstable surficial bedrock. The rocks that form Kohima are mainly of Barail and Disang formations, richly composed of splintery shales, sandy shales, sandstones, coarse sand, clay, chalk, slate, gravels, boulder beds and conglomerates (Thingo, 1994), which are highly pervious rocks with fissures, cracks, bedding planes and joints which causes water to pass freely through the rocks and thus results in crustal instability becoming the core reason for the instability of the region. With the meteorological and geomorphological condition of the region, it is most prone to all kinds of landform hazards such as landslides, flash floods, subsidence, and erosion, mainly due to higher surface run-off as the soils and rocks have poor internal drainage. Ecologically being very unstable and fragile, slight disturbances in hilly terrain may lead to exaggerating adverse impacts of natural hazards (Satendra, 2003). The district has been divided into three central structural units, and they are:

1) The highly dissected hills and valleys are the most prominent along the southern and Northern, western parts of the district. The Highest Japfu Peak of Kohima is found here, and also found are the ranges of Dzukuo. This unit covers part of the Zubza and Jakhama circles of Kohima, and they account for 48% of the district area.
2) The moderately dissected hills and valleys cover the most extensive region and have the highest population density because of their gentle and undulating slope. It accounts for 50% of the district area.
3) The low dissected hills and valleys are the low-lying plains and cover only 2% of the district area in parts of Zubza, Tsogin and Botsa.

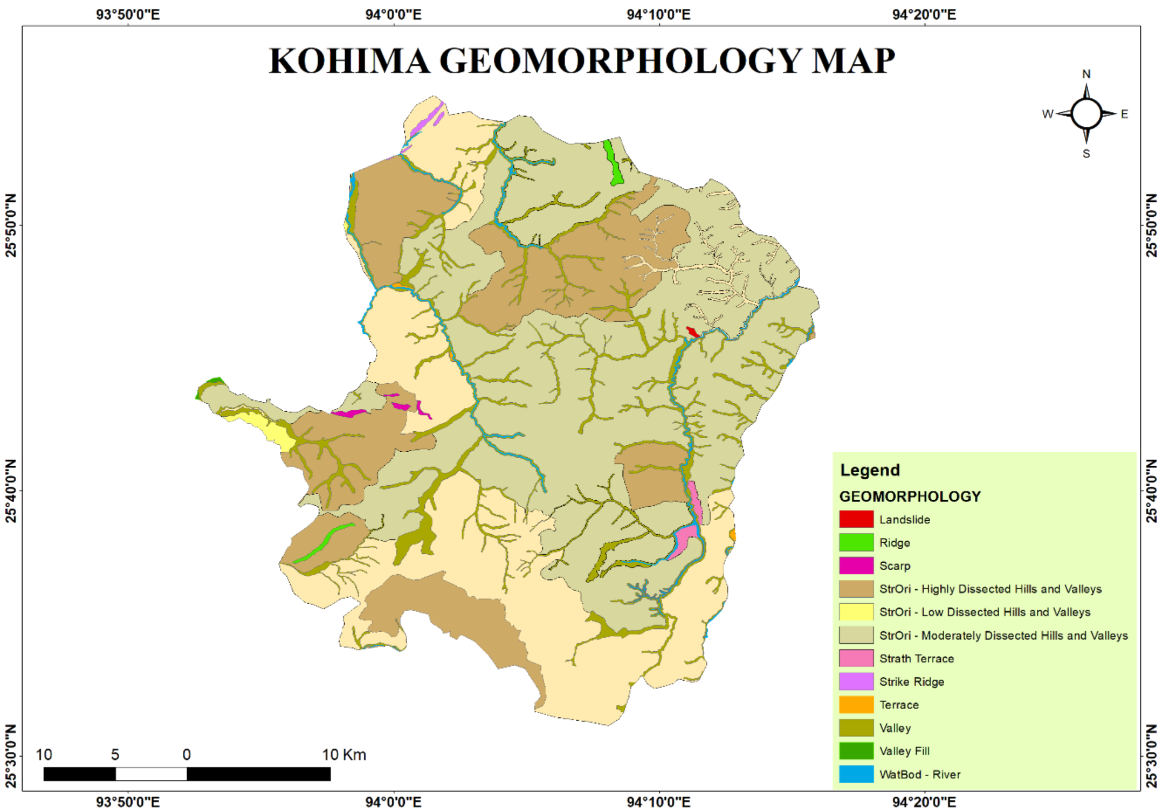

Figure 2: Geomorphological map of Kohima district, Nagaland

Also, with the district expanding demographically, the intensity, frequency, and area of instability of the region increases as it is found that in areas where human activities are high, the instability of the land is more (Thingo, 1994). The population of Kohima district fashions at an increasing rate, with a population count of 99,039, according to the 2011 census. Geomorphic hazards seriously threaten population settlement and critical infrastructures such as roads, bridges, and plants. However, infrastructure development often increases geomorphic activity (Rainer Bell et al., 2020).

Kohima experiences a series of geomorphologically driven hazards and disasters such as flash floods, sinking and landslides and out of which landslide is the most frequent and common hazard the district experiences. Landslide in Kohima is mostly rainfall driven, and thus it experiences a huge number of landslides in and around the district during the pre-monsoon and inter-monsoon seasons. During the monsoon season, it is pervasive for Kohima to witness slumps or earth materials moving downslope for a short distance in various locations. Though the record of lives lost is rare, the damage is done heavily to settlements, infrastructure, roads, and developmental activities. Many slow-moving landslides tend to develop into a disastrous event if not taken care of, and thus there are many settlements in such areas that are at risk of a potentially disastrous event. More than 90% of the district is covered by soil with a high erosivity factor which further explains its tendency towards slope failure.

Sl. No.	Sub-Division	No. of geomorphological calamities
1	Chiephobozou	19
2	Kohima Sadar	45
3	Sechu Zubza	12
4	Jakhama	14
5	Kezocha	9
Total		**99**

Table 1: Total number of geomorphological hazards that occurred in Kohima from 15 May 2017 to 29 August 2018 (source DDMA, 2018)

In approximately 15 months, Kohima is recorded to have experienced a total of 99 geomorphological calamities, of which 90% were recorded to be related to landslides and most affected were settlements, roads, and paddy fields. Flash floods, along with sinking areas, are also a common phenomenon in Kohima.

NH-29 Landslide:

The infamous Old KMC Dumping landslide, or the Dzuchie landslide along NH 29 connecting Dimapur and Kohima, remains active throughout the year owing to continuous subsidence, which is further intensified during the monsoon season due to incessant rainfall.

A 2km stretch has been studied and analysed, falling within the coordinates 25º40'59.19" to 25º41'17.85” N latitude and 94º04’20.17” to 94º03’32.26” E longitude.

This slide found here is an extensive debris flow and falls in the Disang-Barail Transition zone, and they are primarily and entirely shale and sandstone. The area is dominated by complex folding and faulting with local asymmetrical folds. This creates differential permeability and shear strength within the same lithology, thus promoting water percolation and forming shallow perched aquifers, thus leading to slope failure.

The slope is less than 15^o-25^o which is favourable for major landslides (DGM, 2011) as it facilitates longer water retention leading to saturation of overlying mass and rise in the perched groundwater level. Due to its rich groundwater, the area is unlikely to stabilise until all is removed.

Due to its geomorphological setting, this landslide has been an active slide, and recent occurrences that are accounted for here were in 2011, 2018 and 2019.

Rainfall in 2011 was more than 1700mm, and thus owing to its geomorphological setting, the slide must have occurred. However, after that, there was a gap of 6 years, and then in 2017, the slide activated excessively, causing enormous loss owing to heavy rainfall of more than 2000mm for the said years of 2017 and 2018, which was recorded to have experienced the highest rainfall between 2011 to 2021.

Subsequently, the slide continued in 2019, also owing to anthropogenic activities such as earthwork due to road construction. Road construction is said to require the removal of 60000m3 of debris for a 1 km length of the road, which is very damaging for hilly terrain. Road sites have erosion 10x more than agriculture, 200x more from grassland, and 2000x more from forest cover land. Dumping of road-cut material puts excessive pressure on land.

The landslide here has become extensive and causes road blockades almost every year during the monsoon

season causing a great deal of inconvenience for trade and transportation as it serves as the road linkage between Assam and Manipur and is the primary source of transport and communication for the entire state and the neighbouring states alike. This NH-29, beyond the selected area of study, also experiences similar calamities as we move towards the southern part of the district along the road, thus causing considerable losses in terms of agriculture, damage to properties and inconvenient means of transportation.

Table 2: General stratigraphy of the study area

Age	**Group**	**Formation**	**Lithology**
Oligocene to Upper Cretaceous	Barail and Disang Transition Zone	Lower Barail Upper Disang	Shale-sandstone, Sandstone-Shale and sandy lamination

Figure 3: Dumping of materials along the NH-29 highway due to road construction.

Figure 4: Indigenous treatment of landslide by bamboo hammering downslope of NH-29

Management and Mitigation:

There are several practices of management and mitigation of such road landslides which pertain in almost every part of Kohima and thus can be applied in general.

Monitoring areas with high and steep slopes is of great help in identifying areas with the tendency to slide.

Development in the form of road construction in all parts of the district has proven detrimental in posing a severe threat for landslides to occur more in intensity and frequency. Therefore, measures with scientific knowledge should be taken to at least lessen the tendency of calamities to occur, such as the felling of trees only in suggested areas.

Also, the construction of a check dam and retaining wall, wherever one may find it necessary, with provision for water draining and elaborative work on the construction of surface drainage in the entire district, will prevent most landslides and sinking. Drilling of borewells and tube wells can also be adopted in selected areas to reduce pore pressure.

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