6 Mizoram, the Capital of Landslide: A Review of Articles Published on Landslides in Mizoram, India

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Abstract

Mizoram, a northeastern hilly state of India, suffers from heavy landslides every year during monsoon season. Geologically, Mizoram has been formed in the tertiary era predominantly made of unconsolidated sandstone and shale, which are the dominant rock types in these areas. Unplanned and non-scientific urban sprawls are the triggering factors of landslides in Mizoram. Various researches have been conducted on landslide susceptibility analysis and slope instability. The present work presents a review of various such research works conducted in Mizoram to understand the overall nature of landslide's geological, geomorphological, and anthropological aspects. The review revealed that most of the landslides in Mizoram happen along the roadside and are rainfall induced. So, government policy and PWD must consider various factors like slope holding capacity, geological strength, and rainfall distribution at the time of road construction and expansion. We hope the present work will help the researchers, and planners take proper steps toward slope stability in Mizoram.

Keywords

Mizoram · Landslide · Hunthar Veng · Lunglei · Hazard

6.1 Introduction

Natural hazards can be termed as either the likelihood of a relatively stable landmass suddenly altering its state (Scheidegger 1994) or the possibility of a destructive event in a given area and time (Varnes et al. 1984). Among the various natural hazards, landslides are the most destructive, having wide socioeconomic and environmental ramifications (Mengistu et al. 2019). It results from two main groups of factors—the triggering and conditioning factors, which are a combination of various factors like topography, geomorphology, anthropogenic, seismic factors, and geology (Pourghasemi et al. 2018). In landslide susceptibility mapping, the area of study is divided or categorized into various zones based on the likelihood or probability of landslide events occurring depending on the specific

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area's triggering and conditioning factors. This type of prediction method, along with landslide inventory based on past landslides, is an integral part of the landslide hazard mitigation technique since they act as warning systems for necessary steps to minimize the after-effect. It is estimated that worldwide, "3.7 million Km^2 of the surface of the land" and about 5% of the world's population are in constant threat of landslides (Pourghasemi et al. 2018).

Various techniques have been applied over the past 20–25 years to derive the landslide susceptibility evaluation, which can be broadly classified into "inventory-based, expert evaluation (Raghuvanshi et al. 2014; Guzzetti et al. 1999; Turrini and Visintainer 1998; Sarkar et al. 1995, Anbalagan 1992; etc.), statistical (Girma et al. 2015, Biswas et al. 2021; etc.), deterministic (Fall et al. 2006), and distribution-free approaches (Kanungo et al. 2006)." Each of the techniques has produced its own set of landslide susceptibility maps, each having its own set of strengths and lacunae. Very few review studies have been conducted to compare the various techniques and find out the limitations of each. The majority of research projects focus on determining the landslide hazard or susceptibility zonation of a specific study area.

The main objective of the present research work is to provide a detailed review of the various researches that have been conducted on landslide susceptibility or zonation in Mizoram, which happens to fall under seismic zone 5. No such work has been conducted till date for the study area, and the present work will thus be a pioneering work toward the same.

6.2 Background

Mizoram, the land of Mizos, is a hilly state situated in northeast India. Mizoram is geographically located between 21° 58′ N and 24° 35′ N latitude and 92° 15′ E to 93° 29′ E longitude. Undulating and rugged topography is the common physiography here. Including Tlawng, Mizoram has 23 major watersheds, of which some are north flowing, while the rest are south flowing rivers (Verma 2018). Mat, Tlawng, Tuivai, Khawthlang -tuipui, Tuirai, Tuirini, Tuirial, Tiau, and Tuivawl are the major drainage systems in Mizoram. Barman (2021) identified drainage systems with trellis, parallel, and dendritic patterns, indicating a strong geological relationship. Mizoram belongs to the Tertiary Barail, Surma, and Tipam groups, with a thickness of 800 m (Barman and Rao 2021). The Mizo hills are characterized in a north–south direction by having a continuous and discontinuous syncline and anti-syncline formation with a strike direction of N15 E to S15° W. Work on the Sangiang fault area, which has an active tectonic collision footprint between the Indo-Burmese plate (Barman and Rao 2021), has been conducted. The Geological Survey of India demarked Mizoram as Zone V which indicates a very high damage risk zone. Mizoram comes under the direct influence of the southeast monsoon. The average annual rainfall is 2500 mm. It received heavy rainfall in July (439.4 mm) and the least in the month of March (3.2 mm), as recorded in 2020 (Directorate of Economics & Statistics, Government of Mizoram).

Mizoram faces numerous natural hazards as well as landslides due to diversity in geology, geomorphology, rapid urban growth, and heavy rainfall during the monsoon season, as shown in Table 6.1. For disaster mitigation and RH, the Mizoram government classified Mizoram into five landslide hazard zones, as shown in Table 6.2.

The majority of landslides in Mizoram occur along the roadways, as observed in Fig. 6.1 and are rainfall induced. Most landslides were caused by rapid urbanization and road construction along oblique to dip slopes. Due to heavy rainfall in Mizoram and many fracture zones in the rocks, the rain enters the cracks and crevices and acts as a lubricating and driving force for landslides.

6.3 Discussion

According to the reviews and inventory data provided by the Geological Society of India, it has been found that the whole of Mizoram is a

Table 6.1 Hazard in Mizoram

Nature of calamity	Human causality		House damaged		
	Deaths	Injuries	Fully	Severely	Partially
Landslide	68	37	600	313	659
Fire	20	21	775	161	386
Flood	14	–	1016	84	1327
Hail storm	–	–	50	115	1432
Storm	–	–	142	102	1496
Cyclone	5	2	687	586	2813
Cloud burst	-	1	3	1	11
Lightening	4	–	–	2	2
Earthquake	–	–	1	–	–
Total	111	61	3237	1364	8126

Source Pachuau et al. (2020)

Table 6.2 Landslide hazard class and their corresponding area

Hazard classes	Area	Percentage (%)
Very high	1822.48	8.65
High	4263.79	20.22
Moderate	8903.47	42.24
Low	5011.57	23.77
Very low	968.72	4.60
Water body	111.97	0.53

Source Pachuau et al. (2020)

landslide-prone area. In the state, the capital district—Aizawl has been ranked first in landslide frequency, followed by the Lunglei district (Fig. 6.2). After Aizawl, Lunglei is the second largest and fastest growing district in terms of urbanization. In both the districts, rainfall and unscientific slope uses have led to increased cases of landslides. The majority of landslides were sliding, followed by fall, flow, and subsidence.

In his case study, Chenkual (2015) studied the incidences of landslides in Laipuitlang, Aizawl. He ascertained that human activities in the hill slopes are the primary reason behind the landslide.

Geologically, the Laipuitlang area falls under the middle Bhuban formation of the Surma group, having a steep slope (43–47) with a strike direction of N40˚ E and N45˚ E. Heavy rainfall with 2064 mm was recorded in Laipuitlang in 2012, resulting in a long crack in the rock bed. Further, heavy construction was also observed, and this has been learned to be the main cause behind the landslides in this region. This tragedy resulted in the total destruction of 15 buildings and the loss of the lives of 8 people.

Verma (2014) also did landslide hazard zonation on the Laipuitlang location. He found that excessive seepage between joints and heavy construction on a hill slope triggered the landslide in the Laipuitlang area. Rao and Verma (2017) reported nine prominent landslide sites along with Aizawl city to Lengpui airport road. They further added that lack of proper drainage and rainfall monitoring systems was the primary reasons for landslides along this section. Hunthar Veng, a subsidence and landslip site region, present along the above-mentioned road section, has been classified as a highly susceptible zone (Plate 6.1). Another study was done by Pandey et al. (2017) in the Aizawl district. Due to slope cutting, major landslides also happened along the road side within the upper Bhuban formation. It has been found that landslide densities are higher

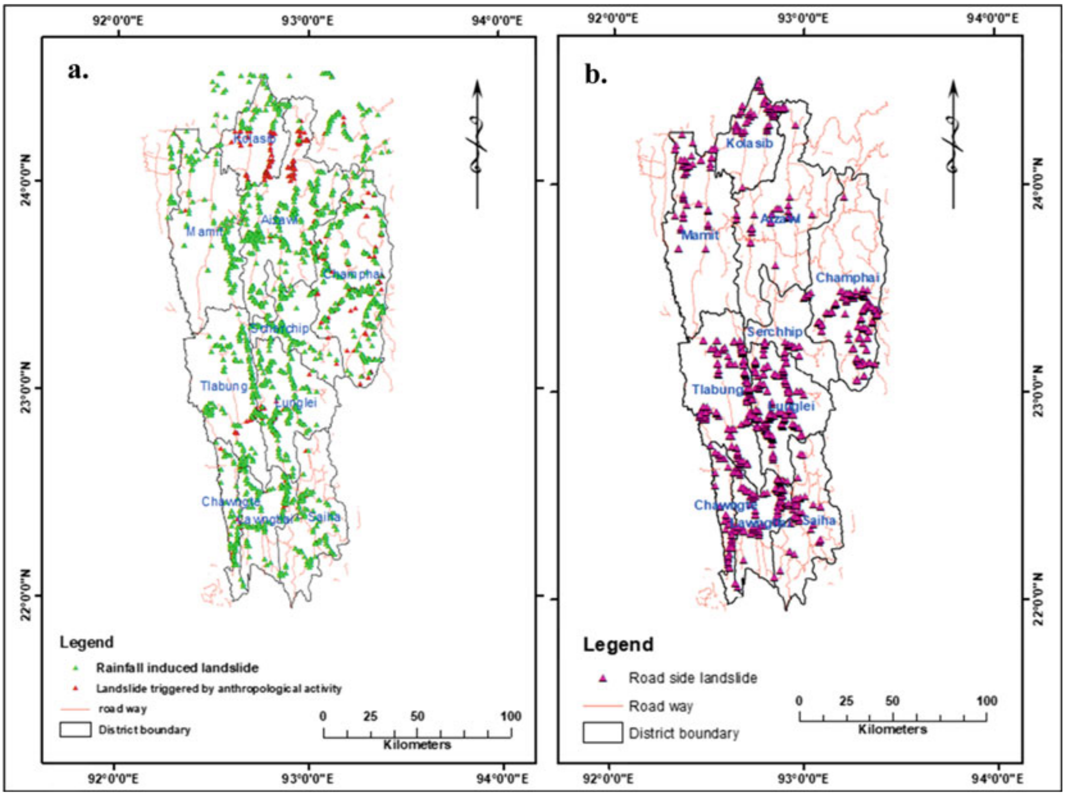

Fig. 6.1 Landslide distribution in Mizoram, **a** distribution of landslide that induced by rainfall and anthropological factors, **b** distribution of landslide that happen along roadside

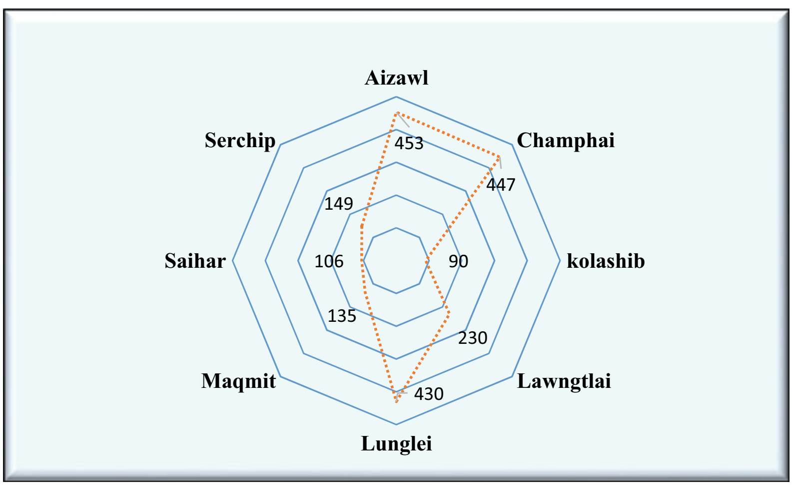

Fig. 6.2 District wise landslide distribution in Mizoram

in areas in between high and low drainage density areas. Srivastava et al. (2002) considered geomorphology, lithology, slope, transport network, and settlement locations while finding out the landslide hazard zones of Aizawl district. They emphasized plantation and a ban on any type of construction to increase slope stability. Rakshit and Bharali (2018) studied the rock fall

Plate 6.3 Hunthar Veng subsidence area

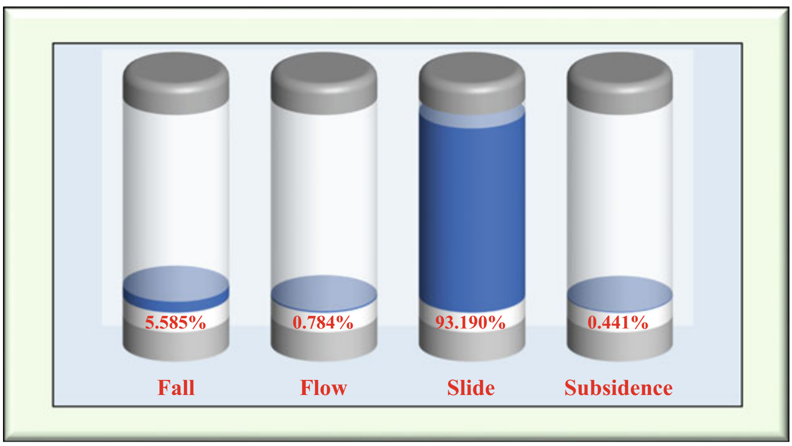

Fig. 6.3 Types of Landslide in Mizoram

hazard and risk assessment of the Aizawl-Durtlang road section. It is a sandstone area, with the bedrock being 10 m thick. They considered topography, slope, stream pattern, slope direction, and rock strength for risk assessment. The in situ geotechnical technique was used to measure the rock strength by them. Their study found that wedge failure was the most dominant type of failure in this road section (Fig. 6.3).

Kumar and Singh (2008) studied landslide hazard and development planning in Lunglei town using total estimated hazard (TEHD) values and discovered that only 0.61% of Lunglei town is in a high hazard zone, followed by 2.44% in a moderate hazard zone, 6.94% in a low hazard zone, 79.17% in a very low hazard zone, and 10.17% in a very low hazard zone. Lallianthanga et al. (2013) have also done a study on Lunglei town using the BIS guidelines of the Geological Society of India. Their study revealed that Rashi Veng, Hauruang, College Veng, the eastern side of Bazar Veng, and Theirat areas are the most prone to landslides.

Khullar and Chakraborty (2002) did a study in the Lawngtlai and Saiha town areas, Mizoram. According to their study, slope gradient was the most important causative factor of landslides. They used gradient changing points as the basis of landslide hazard zonation. An equal slide contour value of more than 25 indicates a high hazard zone; an equal slide contour value of 10–25 indicates a medium landslide zone, and a contour value of less than 10 indicates a low landslide hazard zone.

Verma and Blick (2018) did landslide hazard zonation along the Thakthing Veng road section using the landslide hazard evolution factor rating scheme. Geologically, the Thakthing Veng area consists of soft shale, siltstone, shale, and silty shale. Due to insufficient drainage planning, they reported that changes in the shale layer resulted in the same being the major driving force of landslides in the area. Using total estimated hazard, they marked the Thakthing road section as a very hazardous zone.

Lallianthanga et al. (2013) studied Mamit town, Mizoram on landslide hazard zonation using GIS and RS. According to the study, unplanned urbanization in the hilly area is the major triggering factor of landslides in Mamit. Severe landslide and subsidence events happened in 2010 due to heavy rainfall in Mamit town. About 43 houses and 50 families were damaged due to landslides that occurred in 2010. Unconsolidated slope material with a high slope angle was found to be the triggering factor of landslides in Mamit town. They divided the whole town into five susceptibility classes, and found that only, 1.78% of the area was in the very low susceptible zone. They suggested that the town could be pushed toward a severe landslide-prone area without proper monitoring and planning.

Pachuau (2019) worked on susceptibility and risk assessment of landslides in Serchip, Mizoram. He used the technique of GIS weight approach, considering geological structure, slope, house type, lithology, etc. He divided the Serchip town area into five susceptible classes.

Kumar et al. (1996) discussed the instability problem in important sandstone quarries in south Hlimen, Mizoram. On August 9th, 1992, the region faced severe rockfall. Their study emphasized the presence of joints, and they suggested excavation of sandstone initiated from top to bottom instead of piedmont.

Sarkar and Samanta (2017) did a stability study at the Keifang landslip area. A dominant landslide site, Keifang, is situated 66 km south-east of Aizawl city. The landslide was recorded in February 2014. Although no rainfall occurred in February 2014, excavation works led to landslides due to slope instability. Another slide occurred in the month of April 2014. The main cause of the slide was identified as cracks at 2–3 m depth. A RCC study revealed that the Keifang landslide area has an unstable slope. Retaining wall or gabion wall was suggested at the foothill of the slope to resist future movement.

Sardana et al (2019) discussed the slope stability in the Kulikawn to Saikhamakawn road section, Aizawl. In Mizoram, heavy rainfall, tectonic forces, and earthquakes are responsible for slope instability as well as a landslide. They used the techniques of slope mass rating, geological strength index, and continuous slope mass rating to understand the nature of instability. The study shows that the area is not stable. Maximum displacement and maximum velocity were recorded at 0.79 m and 0.76 m/s, respectively. A numerical two-dimensional model was applied in 11 locations to determine the failure types. Wedge failure was the dominant sliding type observed along the abovementioned road section.

6.4 Conclusions

This review paper was done on landslides in the geological, geomorphological, and anthropological aspects of Mizoram. The review reveals that Mizoram is situated in a moderate-to-high susceptible landslide hazard zone. Proper monitoring, management, and awareness can reduce this risk. From the various reviews and inventory of landslides from Bhukosh, it is found that most of the landslides occur along the road section and are rainfall induced. In Mizoram, Aizawl has the highest incidence of landslides, followed by Lunglei. The reason can be attributed to unscientific urban growth without considering slope stability measures. Vegetation cover can protect soil erosion and restrict landslides. The use of Vetiver grass and bamboo, both of which grow abundantly in Mizoram, can help work as a binding agent for the landslide-prone slopes of Mizoram. Improvement and awareness of indigenous knowledge (Changkham) and community-based work are suggested to reduce landslide risk for Mizoram.

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