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Landslide Hazard Zonation (LHz) of Lawngtlai District, Mizoram, India Using Remote Sensing and GIS

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ABSTRACT : Lawngtlai district, Mizoram is prone to natural hazards like landslide, earthquake, etc. Landslide is one of the natural disasters, which involves sliding of mass of earth or rock down the slope along a definite zone or surface. Landslide Hazard Zonation may be defined as a technique of classifying an area into zones of relative degrees of potential hazards by ranking various causative factors operative in a given area based on their influence in initiation of landslides. Landslide Hazard Zonation map is prepared based on the integration of data acquired from various geo-environmental thematic databases. Combining various controlling parameters by giving different weightage value for all the themes, the final map is derived in a GIS environment on 1:50,000 scale. The area and the map is then classified into Very high, High, Moderate, Low and Very low hazard zones. Very High Hazard Zone constitutes an area of 221.82sq. km and forms 8.67% of the total district area ; High Hazard Zone occupies a fairly large area i.e, about 446.76sq. km which is 17.47% of the total district area; Moderate Hazard Zone constitute an area of about 1084.30sq. km and occupies 42.41% of the total district area; Low Hazard Zone extends over an area of about 597.0sq. km and forms 23.35% of the total district area and Very Low Hazard Zone covers an area of about 188.67sq km and forms 7.38% of the total district area.

KEYWORDS : Landslide, Hazard Zonation, geo-environmental Parameter, Geological features, Thematic layers

I. INTRODUCTION

Lawngtlai district is located to the south-western part of Mizoram between 22° 47' 08.89" and 22° 26' 32.65" N Latitudes and 92° 31' 03.29" and 92° 58' 50.86" E Longitudes. It is bounded to the north by Lunglei district, on the south by Myanmar and part of Bangladesh, on the east by Myanmar and Saiha district, and to the west by Bangladesh. The total geographical area of Lawngtlai district is 2,557 sq. Km, and falls in the Survey of India Topo sheet Nos. 84 B/9, 84 B/10, 84 B/11, 84 B/12, 84 B/13, 84 B/14, 84 B/15, 84 B/16, 84 F/1, 84 F/2, 84 F/3 and 84 C/9.

Lawngtlai district is prone to natural hazards like landslide, earthquake, wind & cyclone and flood. Various geological and geophysical settings, climatic, meteorological and hydrological condition of the area induces the occurrence of these natural hazards. Anthropogenic processes such as developmental activities i.e, construction of buildings, roads and other infrastructures can influence the natural forces to manifest as hazards.

Landslide is one of the natural disasters, which involves sliding of mass of earth or rock down the slope along a definite zone or surface. Landslides attain specific significance because of their widespread occurrence resulting in great loss to public due to both direct and indirect consequences. Their occurrence becomes more vexatious because of its unpredictability in both time and space. Hence, due attention should be given in combating this natural hazard. Preparation of Landslide Hazard Zonation (LHZ) map is one of the first steps in this direction.

Landslide Hazard Zonation may be defined as a technique of classifying an area into zones of relative degrees of potential hazards by ranking various causative factors operative in a given area based on their influence in initiation of landslides. Thus, the LHZ of an area aims at delineating the landslide potential zones and ranking them in order of the degree of hazard from landslides. LHZ maps are very helpful for planners, engineers, etc, in identifying and delineating unstable hazard-prone areas, selecting viable sites for carrying out developmental schemes and evolving database for the risk analysis of landslides in the area.

International Journal of Innovative Research in Science, Engineering and Technology

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The study area i.e., Lawngtlai district is characterized by the presence of several lineaments, both major and minor faults oriented in different directions, and steep slopes. The lithology is mainly represented by soft sedimentary rocks, such as shale, silty shale, sandstone and their admixture in varying proportions. Besides, loose and unconsolidated sediments form a dominant composition on the exposed surface, particularly in built-up areas. This, together with the aforesaid factors makes it susceptible to landslides. Therefore, overcoming the problem of this geo-hazard is essential for the safety of life and property and hence hazard zonation is necessary for the district.

II. METHODOLOGY AND DATA USED

Landslide Hazard Zonation map is prepared based on the integration of data acquired from various geo-environmental thematic databases. Of the several methods, Qualitative method is found suitable and has been employed for carrying out LHZ mapping. A qualitative approach essentially depends on expert opinion in dividing an area into different zones of varying landslide susceptibility. The methodology involves several steps which includes detailed geological survey of the area from satellite imagery, SOI topographic maps and also from the ground. It is well known that the occurrence of landslide is mainly governed by the geo-environmental factors of the terrain. As such, these geo-environmental parameters, viz., lithology, geological structures like lineaments and faults, soil type, drainage density, geomorphology, slope and land use/land cover were first mapped from satellite imagery and other ancillary data using visual interpretation techniques. Geological features like faults, lithology and lineaments were extracted from satellite imagery using basic principles of image interpretation involving color, tone, texture, pattern, shape, size and association. The different thematic layers are then subsequently integrated using Arc Info GIS Software. The table indicating the weightage value (on the scale of 1-10) of parameters for landslide is shown in Table No 1.

Parameter	Category	Weight
Lithology	Sandstone	4
	Siltstone & Shale	8
	Shale & Siltstone	9
	Crumpled Shale	10
Land Use / Land Cover	Heavy Vegetation	3
	Light Vegetation	5
	Scrubland	6
	Barren land	7
	Built-up	8
Slope Morphometry (in degrees)	0 - 15	1
	15-25	3
	25-30	4
	30-35	5
	35-40	6
	40-45	7
	45-60	8
	> 60	5
Structure (Faults and Lineaments)	Length of Buffer distance on either side	8
Geomorphology	High Structural Hill	4
	Medium Structural Hill	3
	Low Structural Hill	2
	Valley Fill	0

Table No 1. : Ratings for parameters and categories

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 7, July 2016

Each individual thematic layer is carefully analysed so as to establish its relation to landslide susceptibility. For example, in lithology layer, the crumpled shale unit offers more chance of slope failure than the hard and compact sandstone unit. Similarly, areas located within the vicinity of fault zones and other geological structures are more vulnerable to landslides and other mass movements. For this, areas of 100 m on both sides of all the lineaments including faults are buffered. Likewise, due considerations are given for the relation between landslides and other thematic layers. In addition, proximity to road cutting, location of both old and active landslides, dip amount and dip direction of the rock beds are also considered. Combining all the above controlling parameters by giving different weightage value for all the themes, the final map is derived in a GIS environment on 1:50,000 scale. The map is then classified into Very high, High, Moderate, Low and Very low hazard zones. The area statistics of the landslide hazard zones of Lawngtlai district is given in Table No 2. The Landslide Hazard Zonation map of Lawngtlai district is shown in Figure No 1.

III. RESULT AND DISCUSSION

From the analysis, area statistics of Landslide Hazard Zonation of Lawngtlai district can be shown as follows :-

Hazard Class	Area (sq. km)	Area (%)
Very High	221.82	8.67
High	446.76	17.47
Moderate	1084.30	42.40
Low	597.00	23.35
Very Low	188.67	7.38
Water Body	18.51	0.72
TOTAL	2557.10	100.00

Table No 2: Area statistics of LHZ of Lawngtlai District

Very High Hazard Zone: This zone is highly unstable and is at a constant threat of landslides, especially during and after an intense spell of rain. This is because the area forms steep slopes with loose and unconsolidated materials. Besides, it includes areas located near faults and tectonically weak zones. It also includes areas where unplanned quarrying, road cutting and other human activities are extensively undertaken. The vegetation is generally sparse. The exposed rocks are characterized by numerous bedding and joint planes which facilitate the chance of sliding down along the slope. Therefore, it is suggested not to established any settlement and developmental infrasturcture in this zone as far as possible. This zone constitutes an area of 221.82sq. km and forms 8.67% of the total district area.

High Hazard Zone: It includes areas where the probability of sliding debris is at a high risk due to weathered rockand soil debris covering steep slopes which when disturbed are prone to landslides. Most of the pre-existing landslides fall within this category. This zone comprises areas where the slope aspect and dip direction of the rocks, which are usually very steep, (about 45 degrees or more) are parallel to each other. This makes them susceptible to slide along the slope. Several lineaments, fractured zones and fault planes also traverse the high hazard zone. Areas which experience constant erosion by streams because of the soft nature of the lithology and loose overlying soil, fall under this class. Vegetation is generally either absent or sparse. Owing to the above reasons, this zone is also geologically unstable and should be avoided. This zone occupies a fairly large area i.e, about 446.76sq. km which is 17.47% of the total district area.

Moderate Hazard Zone: This zone is generally stable, though it may contain unstable zones in some areas. Moreover, seismic activity and continuous heavy rainfall may reduce its stability. Though this zone may include areas such as cliffs that have steep slopes (more than 45 degree), the orientation of the rock bed and absence of overlying loose debris and human activity make them less hazardous. In general, this zone comprises areas that have

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moderately dense vegetation, moderate slope angle and relatively compact and hard rocks. This zone is predominantly high in terms of areal extend. It spreads over an area of about 1084.30sq. km and occupies 42.41% of the total district area.

Low Hazard Zone: This includes areas where the combination of various controlling parameters is unlikely to adversely influence the slope stability. In other words, this zone comprises areas where the chance of slope failure is low or unlikely to occur. Vegetation is relatively dense, though some areas may not have vegetative cover. Although some of the areas may be covered with soft and unconsolidated sediments, the slope angles are generally low, about 30 degrees or below. This zone extends over an area of about 597.0sq. km and forms 23.35% of the total district area.

Very Low Hazard Zone: This zone mainly comprises vegetative areas and is located away from human settlement. As such, it is assumed to be free from present and future landslide hazards. The dip and slope angles of the rocks are fairly low. Although the lithology may comprise soft rocks and overlying soil debris in some areas, the chance of slope failure is minimized by low slope angle and vegetation present within its vicinity. This zone covers an area of about 188.67sq km and forms 7.38% of the total district area.

Apart from the various hazard classes, some areas are covered by water bodies which are not included in the hazard classes. Such water bodies cover an area of 18.51sq. km which is 0.72% of the total district area.

From the above, it can be said that Very High Hazard and High Hazard Zone constitutes an area of 668.57sq. km and forms 26.14% i.e one fourth of the total district area. These two zone with Moderate Hazard Zone constitute an area of 1,752.87sq. km and occupies 68.55% of the total district area clearly indicating the vulnerability of the district to landslide. Low Hazard Zone and Very Low Hazard Zone together constitute only 767.67 sq. km, a mere 30.73% of the total district area

IV. CONCLUSION

Being a hilly terrain, the area is prone to landslides and every year a number of landslides are reported from various localities. These cause a lot of problem to public, resulting in loss of life and property, disruption of communication network, and also cause economic burden to the society. Landslide incidents are more prominent during the rainy/monsoon season as the soil structure gets soften by heavy and continuous downpour, especially in high degree of slope. It is suggested that microzonation of the district may be undertaken to map in a smaller scale. It is expected that various line governmental departments must carefully go through the paper for developmental planning process, selection of sites for installation of assets and infrastructure initiatives so that vulnerability to landslide is reduce; prevent loss of lives and property and attain sustainable developments.

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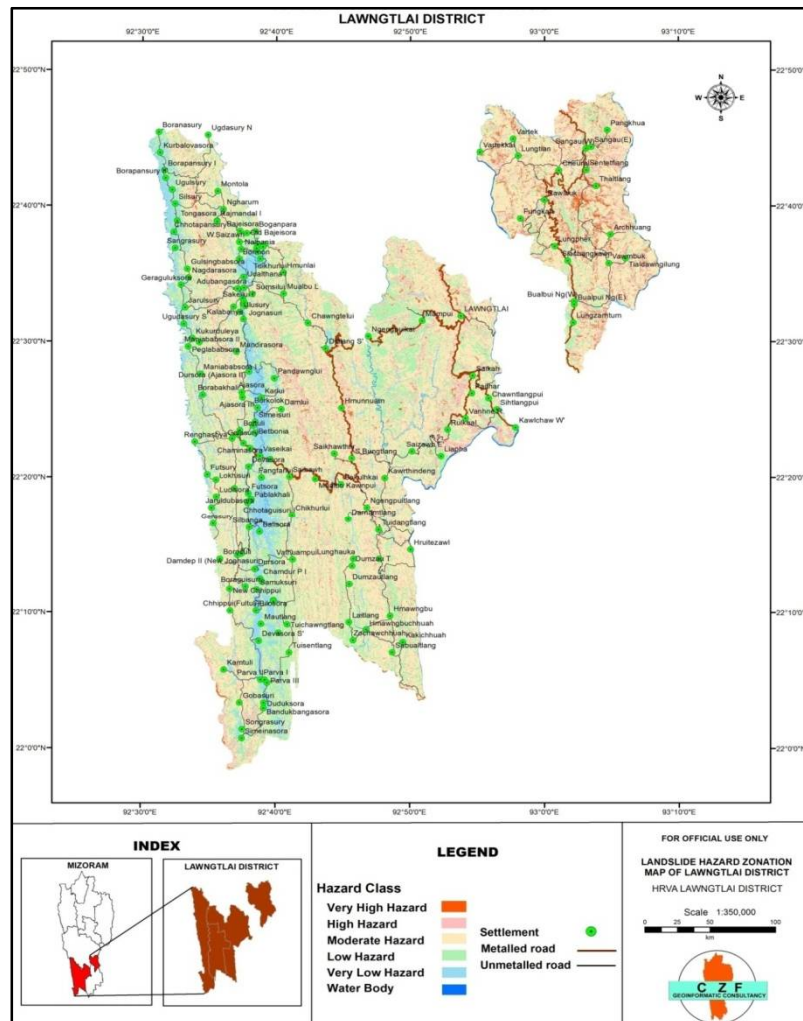


Figure No 1: Landslide Hazard Zonation map of Lawngtlai District

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Vol. 5, Issue 7, July 2016

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