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Landslide Hazard Zonation (LHZ) Mapping of Attappady, Kerala using GIS

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Abstract - *Landslides are common forms of disasters, which include wide range of ground movements such as rock falls, debris flows etc. Landslides are also known as landslips, slumps, slope failure. They are the most common geo-hazards occurring in highland regions, especially mountainous regions. Landslides can be caused by natural factors or by anthropogenic activities, resulting in destruction of environment, damage to buildings, road, railways, pipelines, communication networks, agricultural land etc. The present study area Attappadi block panchayat in Palakkad district, Kerala is prone to landslides, and have been affected by landslides during the past several years. In this study, an attempt has been made to prepare the landslide hazard zonation map based on applied remote sensing (ARS) and geographic information system (GIS) techniques. In this study, seven influencing factors are selected viz. slope, elevation, soil type, drainage density, geology, geomorphology and land use. For the preparation of the landslide hazard zonation zone of Attappadi block panchayat weighted overlay analysis is used. The prepared map shows the areas prone to landslides as 5 zones of varying vulnerability. The Landslide Hazard Zonation map is validated using the landslide incidence points of the study area.*

Key Words: **landslide, GIS, geo-hazards, Kerala, Attappadi, vulnerability**

1. INTRODUCTION

Landslides are natural hazards that can cause severe damage to life and property. It can be defined as the movement of a mass of rock, debris, or down a slope, under the influence of gravity. Landslides have become a major threat in the recent times due to the intervention of human beings. Activities such as deforestation, mining, landfilling, unscientific developmental activities etc. has contributed to increasing the magnitude and frequency of landslides. Also, the natural structure and constitution of some areas make them prone to landslides by default. Although landslides are not as disastrous as major earthquakes, floods, forest fires, hurricane etc, they can be equally devastating at times. Landslides can be induced either by earthquake or rain fall. Kerala receive high amount of rain fall during monsoon which make the slopes of hilly areas vulnerable to landslides. Geological and geomorphological features, elevation, slope stability, surface characteristics etc. play an important role in triggering landslides. Hilly terrains of India, Himalayan Mountains, Western Ghats, and North-Eastern India etc. are hit by landslides almost annually. These landslides cause great misery to the dwellers of such areas and it is almost unavoidable. Landslides cause damage to property, injury and death to men and animals and adversely affect a variety of resources. Damages caused to communication lines, road networks, railway lines, bridges, water supplies, dams etc. can take up years to restore. Landslides can also lead to economical degradation of the affected area. The availability, quantity, and quality of water can be affected by landslides. The objective of this study is to identify the landslide susceptible regions of Attappadi block panchayath. In this study, seven factors viz., slope, elevation, geology, geomorphology, soil type, landuse, and drainage density are selected as controlling parameters.

1.1 Study Area

The present study area, attappadi block panchayath is located between 11°14'23.694"N and 10°54'58.396"N latitudes and 76°23'19.33"E and 76°47'59.054"E longitudes. The total area is 828.9 square kilometers and perimeter is 206.15 kilometers. The region is a part of Mannarkad Taluk of Palakkad district. Attappadi's climate is classified as tropical with an average annual temperature of 24.8°C and precipitation of 1731 mm. Study area is given in Figure 1.

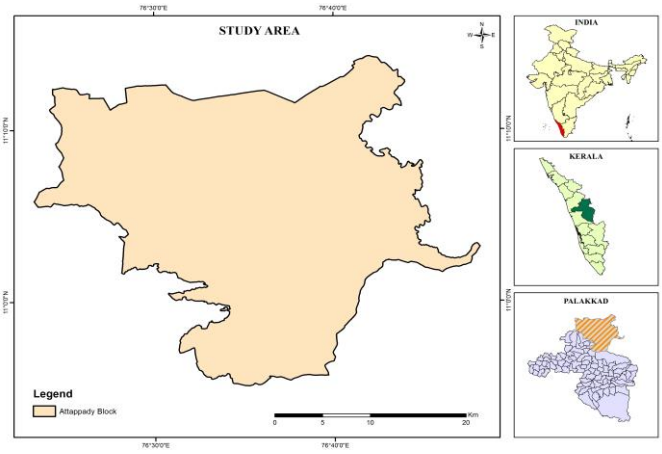

Figure -1: Study Area- Attappadi Block Panchayat

2. MATERIALS AND METHODS

For the present study area, toposheets for geology, soil type, and boundary are collected from Kerala State Remote Sensing and Environment Center, Thiruvananthapuram.

Thematic maps were prepared by digitization using ArcGIS 10.3.1. The landuse/landcover, and geomorphology of the study area is extracted from the Bhuvan Web Map Services (WSM) by Indian Space Research Organization. A WMS is a standard protocol for serving georeferenced map images over the internet that are generated by map server using data from GIS database.

Slope and elevation were derived using Digital Elevation Model (DEM). The data used in the preparation of elevation and slope is of SRTM-1 Arc-Second Global (Shuttle Radar Topography Mission-1 Arc-Second Global). The DEM data is obtained from Earth explorer. The drainage density map was prepared using ArcGIS spatial analyst tools.

To each class of selected factors, different ranks and weights were assigned on accordance to its influence on landslide occurrence. The landslide hazard zonation map is prepared using Weighted Overlay Analysis. The LHZ map is validated using the landslide occurrence points based on field study and the natural hazard zonation map of Kerala, prepared by Kerala State Disaster Management Authority.

Sl No	Factor	Class	Rank	Weight
1	Slope	0-10.654°	5	25
		10.654-18.717°	3	
		18.717-27.067°	3	
		27.067-36.858°	2	
		36.°858-73.428°	1	
2	Elevation	64-565 m	4	10
		565-866 m	3	
		866-1206 m	3	
		1206-1631 m	2	
		1631-2366 m	1	
3	Geology	Peninsular Gneissic Complex	1	17
		Metabasic and Ultrabasic rock	5	
		Migmatite complex	2	
		Charnockite	1	
		High Grade Metasedimentary Rock	5	
		Khondalite	1	
		Pegmatite/Aplite/ Quartz vein	5	
		Basic Rocks	5	
4	Soil Type	Gravelly Loam	2	15
		Waterbody/Tank	3	
		Gravelly Clay	2	
		Clay	1	
5	Geo-morphology	Structural Origin- Highly Dissected Hills and Valleys	2	10
		Structural Origin- Moderately Dissected Hills and Valleys	3	
		Denduational Origin- Highly Dissected Hills and Valleys	1	
		Anthropogenic Origin	1	
6	Landuse	Agriculture	2	13
		Forest	4	
		Built-up area	3	
		Grassland	1	
		Wasteland	1	
		Water bodies	5	
		Wetlands	2	
		Fallow land	2	
7	Drainage Density	0-0.00029 km/sq.km	5	10
		0.00029-0.000612 km/sq.km	4	
		0.000612-.000927 km/sq.km	3	
		0.000927-0.001275 km/sq.km	2	
		0.001275-0.00211 km/sq.km	1	

Table -1: Weightages and ranks

3. RESULTS AND DISCUSSION

3.1 Slope

Slope is one of the most important factors affecting landslide. It is expressed as percentage rise or degree. As the value of slope increases the chances of landslide occurrence also increases. But it does not mean that gentle slopes are not susceptible to landslide. When gentler slopes are combined with other factors, they also become vulnerable to landslide. The slope of the study area is divided into seven classes viz., 0-10.654°, 10.654-18.717°, 18.717-27.067°, 27.067-36.858°, 36.858-73.428°. The thematic slope map is given in Figure 2.

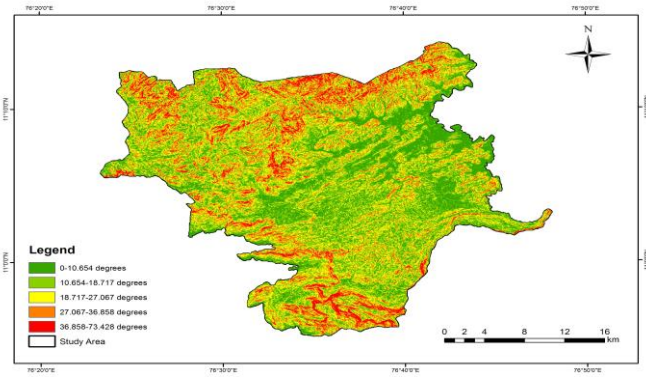

Figure -2: Slope Map

3.2 Elevation

Elevation is another natural factor that causes the downfall and sliding of rocks and debris. In areas of higher elevation, the probability of landslide occurrence is relatively higher than that of lower elevation. In areas of lower elevation terrain is generally gentle and a high water table will be required to initiate slope failure. In this study area the elevation above mean sea level ranges between 64-2366 m. The higher elevation areas are mainly concentrated towards the North and north-west parts of the study area. The thematic elevation map is given in Figure 3.

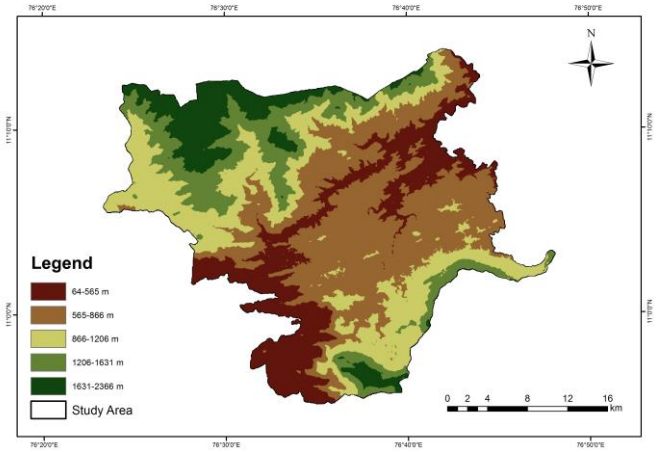

Figure -3: Elevation Map

3.3 Soil Type

The properties of the soil present in an area greatly affect the landslide occurrence. Presence of sandy soil makes a region vulnerable to landslide, owing to its quick response to water which causes it to slide. Different types of soil in the study area were assessed and given suitable ranks according to its influence on landslide. The thematic soil type map is given in Figure 4.

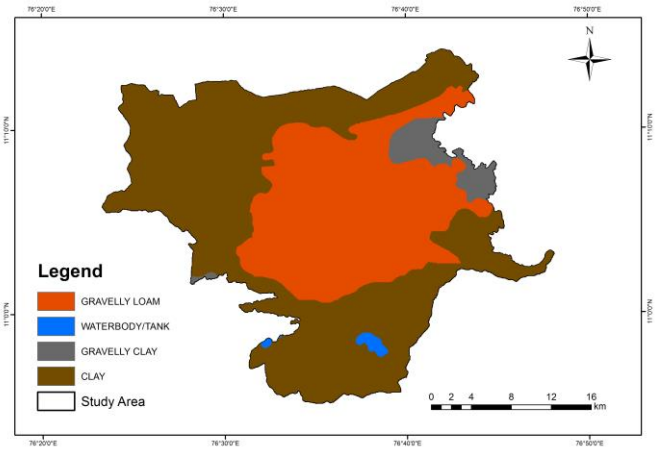

Figure -4: Soil-Type Map

3.4 Geology

Areas which are characterized by week, poorly consolidated and incompetent type of rocks are prone to landslide. Presence of strong, stable and hard rocks imparts stability to the slope, making them less susceptible to landslide. The natural strength of rocks can be affected by the presence of joints, fractures, extent of weathering etc. the rock types present in study area are basic rocks, charnockite group of rocks, high grade metasedimentary rocks, khondalites, metabasic and ultrabasic rock, migmatite complex, pegmatite/aplite/quartz vein and peninsular gneissic complex. The khondalite and peninsular gneissic complex are more prone to landslide owing to its weathering properties. The thematic geology map is shown in Figure 5.

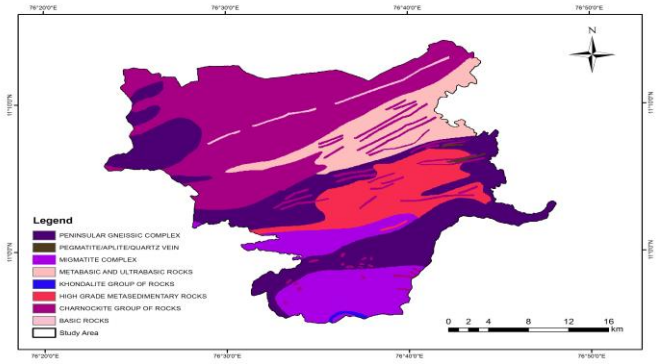

Figure -5: Geology Map

3.5 Geomorphology

Geomorphology is the study of surface features of earth crust involving interpretative description of landforms, their origin and development and nature and mechanism of geomorphological processes which evolve the landforms. The main geomorphological features of the study area are structural origin- moderately dissected hills and valleys, structural origin- highly dissected hills and valleys, denudational origin-highly dissected hills and valleys and anthropogenic origin. Denudational origin surface features are more prone to landslide than that of structural origin. The thematic geomorphology map is shown in Figure 6.

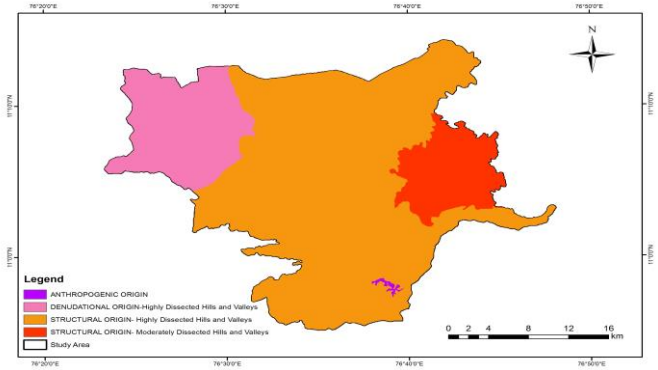

Figure -6: Geomorphology Map

3.6 Drainage Density

Drainage density is a factor which is indicative of perviousness of strata, rainfall, vegetation and stream incision. All these factors are directly related to mass movement. High drainage density is an indication of impervious strata, high rainfall, less vegetation and active stream incision. The thematic drainage density map is shown in Figure 7.

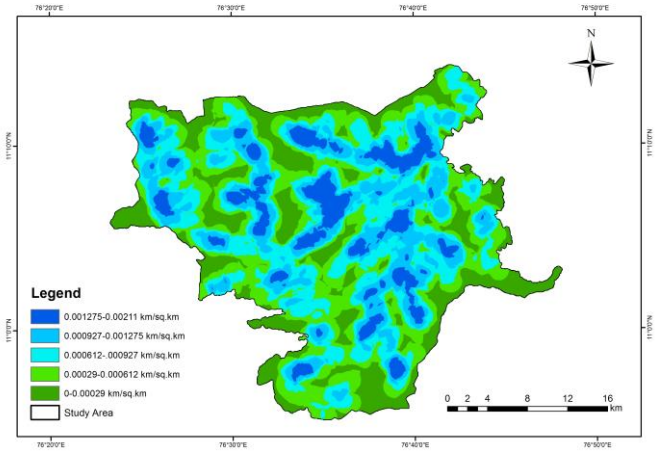

Figure -7: Drainage Density Map

3.7 Landuse

Landuse/Landcover is one of the key factors affecting landslide. Often, the changes brought by anthropogenic activities cause rapid changes in the stability of a landform. Activities like deforestation, unscientific cultivation practices, urbanization, land reclamation etc. influence the incidence of landslides. Areas with sparse vegetation are more prone to landslide in contrast to densely vegetated areas due to more erosion. Chances of landslide depend upon the amount of water infiltrated to geomorphologically unstable slopes with loose soil and weak rocks. The thematic landuse/landcover map is shown in Figure 8.

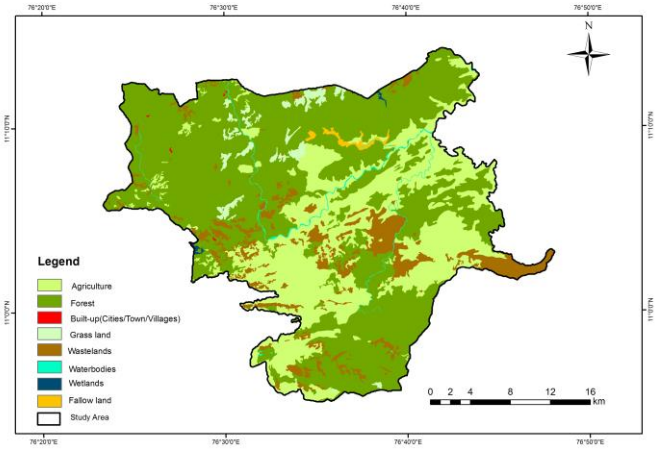

Figure -8: Landuse Map

Based on the weighted overlay analysis done on the seven selected parameters, the output map is generated. The study area is thus classified into 5 zones with varying vulnerability viz., very high susceptible zone, highly susceptible zone, moderately susceptible zone, low susceptible zone and very low susceptible zone.

4. CONCLUSION

Regions like Attappadi where the population density is less, the preventive measures taken for the recurring landslides are relatively low. When landslides and such disasters hit them, usually people get isolated. The communication and transport systems often get hindered making their life miserable during the time of such disasters. Using remote sensing and GIS techniques, effective demarcation of landslide hazard zones can be done. Thus the mitigation measures can be precisely done and the management of landslide hazard is made easy.

From this study it is found that the north, north-eastern and the southern regions of Attappadi block panchayat are more prone to landslides. It is clear that slope and elevation are the most important causative factors followed by drainage density, geology, soil type, geomorphology and land use. The prepared landslide hazard zonation map is validated based on the natural hazard zonation map of Kerala, prepared by Kerala State Disaster Management Authority. Hence this methodology can be used for further studies on other regions.

The prepared LHZ map may be useful to planners and developers for choosing suitable site for future developments and landuse planning, and also to locate constructions in the unstable zones. It could be of use for authorities of the area for ensuring safety to the people of affected regions.

Constant monitoring for geo-hazards is necessary in strategically important places and location of major dams, pipelines, important structures and monuments. Hazard zonation mapping using GIS and remote sensing techniques provide latest and reliable information regarding the same.

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