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Landslide Hazard Zonation Mapping Using Geo Spatial Technology in Bodimettu Hills, Theni District, Tamil Nadu, India

NAVEEN RAJ T[1], PRABAKARAN K[2], UDHAYAGOWTHAM G[1], MAHESH KUMAR M[1], ARAVIND D[3] AND SARAVANAVIKASH A[1]

[1]*Department of Civil Engineering, Velammal College of Engineering and Technology, Madurai, India*
[2]*Department of Oceanography and Coastal and Studies, School of Marine Sciences, Alagappa University, Thondi Campus- 623409*
Email: *naveengeoster@gmail.com*

Abstract: Landslides are often destructive and periodically affect the Bodimettu district. The landslide events not only cause fatalities but also damage to road, buildings, vehicles, etc. and affect the society by disturbing the utility services and economic activities. Rainfall is one of the triggering mechanisms for the landslides and most of the landslide incidents correspond to peaks in rainfall which have occurred when the area was saturated with antecedent rainfall. Thematic maps were prepared on the various causative factors that is geo-system parameters like geology, lineaments/faults, geomorphology, land use/land cover, drainage system, slope, etc. High resolution Geo-eye satellite data, LANDSAT - TM and ASTER images have been used to generate thematic maps. The events have taken place mainly during North West (NW) monsoon during the months from October to December and only few slides have occurred during South West (SW) monsoon even if there is excess precipitation. The Possibility of landslide occurrences is due to improper drainage system, lithology, Intensive Rainfall, High slopes with no vegetation etc. The study also highlights the need for maintenance of landslide database and installation of more rain gauge stations to update and improve the Land Hazard Zonation (LHZ) maps to reduce the risk of landslide hazard faced by the human community.

Keywords: *Mapping, LHZ, Remote Sensing and GIS*

1. Introduction

Landslide is defined as the "the movement of mass of rock, debris or earth down a slope" (Cruden 1996). Varnes (1958) defined landslides as the downward movement of slope forming materials composed of rocks, soil or artificial fills. According to Bell (1992) landslide occurs because of the forces creating movements and it's exceed those resisting forces. Landslides are frequently responsible for considerable losses of both money and lives in mountainous terrains and the severity of the landslide problem worsen with increased urban development and change in land use. Landslides pose serious threats to human settlements and their infrastructure including developmental programmers such as power projects, highways, railways, waterways, pipelines etc. Slope, climate, nature of rocks, earthquakes, topography etc., are said to be the principal nature factors instrumental for landslides. But the anthropogenic activities in the form of massive development seem to trigger the landslide more in hill systems. Landslide Hazard Zonation (LHZ) refers to "the division of a land surface into homogeneous areas or domains and their ranking to degrees of actual/potential hazard caused by mass-movement" (Varnes, 1984). In the recently various methods and techniques have been proposed to analyse causative factors and produce maps portraying the probability of occurrences of similar phenomena in future. Landslides are regarded as natural degradation processes as stated (Van Westen, 1994) produced by natural and human activities. The complete landslide hazard assessment requires an analysis of all these factors leading to instability in the region. Then the spatial and temporal thematic in formations derived from remote sensing and ground based information need to be integrated for data analysis. This can be very well achieved using GIS which has the capabilities to handle voluminous spatial data. Geographic Information System(GIS) is a system of hardware and software and personnel to help to manipulate, analyze, and present information which is tied to the spatial location. GIS is the method to visualize, analyze, manipulate and display the spatial data along with the help of GIS, it is possible to integrate the spatial data of different layers to determine the influence of the parameters on landslide occurrence. There are several publications on landslide instability using geospatial technology Carrara et al., (1995); Guzzetti (2000); Dai et al., (2002); Van Westen et al., 2000, 2005; Carrara and Pike (2008).

2. Study Area

Based on the Statistical data, landslide is the most damaging hazard. They cause extensive damage to roads, bridges, human dwellings, agricultural lands, forest and communication network, etc., resulting in loss of property and its environ. Bodi-Bodimettu Ghats section is an important inter-state network connecting Theni (Tamilnadu) and Munnar (Kerala), where the traffic volume is always high. This road was converted National Highways 49 Extension in the year of 2006. There were small rock fall reported in this route before NH conversion. After the conversion processes of widening from the single to double lane, it was observed that many landslides occur. Many of the slopes along this route are steepened to almost vertical cuttings and overhangs.

Bodi-Bodimettu Ghats section is located on the Megamalai Hills of Western Ghats. A stretch of bodimettu is 19-km and 17 hairpin bends have been taken for analytical study. The slope area covers about 10.09 km2 of Puliuttu Ar. sub-watershed. The landslide activities are rampant on the hill slopes of Puliuttu Ar. Sub-watershed. Present study area fallows under latitudes10°00′53″ and 10°03′11″ N and longitudes 77°15′04″ and 77°18′53″ E (Fig.1). The study area falls under the Survey of India Toposheet no. 58 F8/SW (1:25,000 scale).

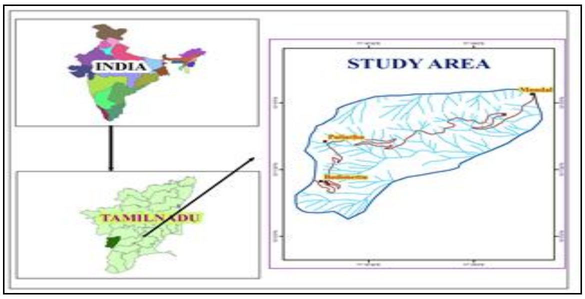

Fig.1: *Base map of the study area*

3. Geology

The Ghat section is composed of a wide assemblage of slight to moderately weathered charnockite, granite, and hornblende biotite gneiss under Archean group. Granite is well exposed and covered in the northern part, highly jointed charnockite covered in the east and southeastern part, and hornblende biotite gneiss covered in the western part (Fig.2). The weathered nature of the rocks has induced the instability of hill slopes. The structural map has been prepared from the aerial photographs and satellite imageries with limited field check.

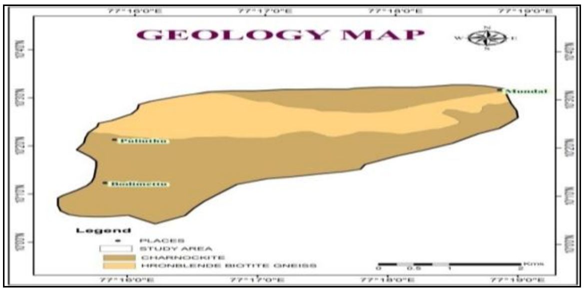

Fig. 2: *Geology map of the study area*

4. Drainage

The detailed geomorphology map was derived from the aerial photographs and satellite imageries with limited field check. Most of the areas were covered by the structural hill. Eastern portion covers smaller areas of debris slope and bajada (Fig.3). The investigation of hill slope morphology, as both a cause and effect of mass failure, has a long and distinguished history (Thornes and Ayala 1998). Geomorphology yields terrain information, which is a vital step in learning the process of landslide initiation.

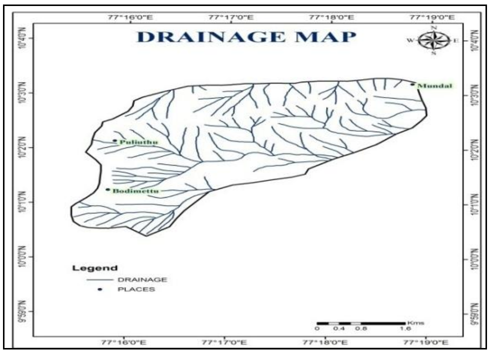

Fig.3: *Drainage map of the study area*

5. Geomorphology

The detailed geomorphology map was derived from the aerial photographs and satellite imageries with limited field check. Most of the areas were covered by the structural hill. Eastern portion covers smaller areas of debris slope and bajada (Fig.4). The investigation of hill slope morphology, as both a cause and effect of mass failure, has a long and distinguished history (Thornes and Ayala 1998). Geomorphology yields terrain information, which is a vital step in learning the process of landslide initiation.

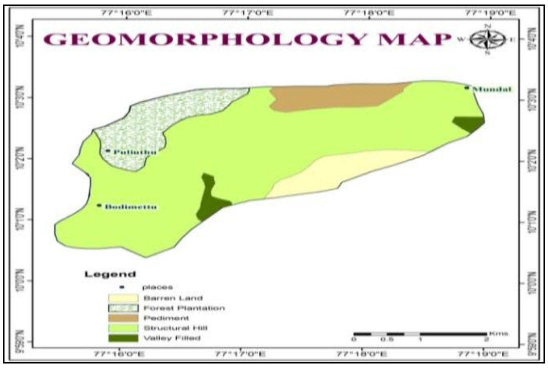

Fig.4: *Geomorphology map of the study area*

6. Land Use / Land Cover

The land use map was prepared using IRS-1C LISS III satellite image of the year 2009. Land use was grouped into seven categories (Fig.5) interpreted with the help of land use/land cover classification framed by NRSC (Anon 2006) such as settlement, agricultural plantation, dense forest, deciduous forest, degraded forest, scrub land, and steep slope. Most of the study area is covered by agricultural plantation like coffee, cardamom, degraded forest, and dense forest. In the western portion of the area, the dense forest, southern central portion covers plantation, and eastern side presents degraded forest. The settlement is located in Bodimettu and Puliuttu area.

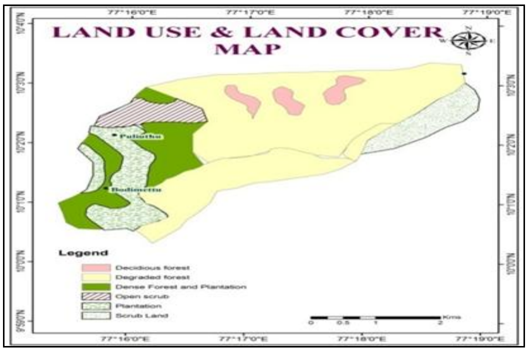

Fig.5: *Land use and Land cover map*

7. Methodology

The present study involves in generating complete spatial and non-spatial data collected from different sources. However, village level maps will act as a basic spatial data contributing many micro level features. Other sources are Remote Sensing data which will undergo digital image processing to build themes on land use, slope, geology, lineament, drainage etc and these items will be victories' to send it to GIS environment. GPS will also act as data source to some aspects which are not available. Finally, in GIS, weight age will be allocated to each parameter by considering their contributions to the landslides and overlay analysis will be carried out. On executing this, the final result will help in prioritizing area prone for landslides with triggering parameter. This database will act as base data for future monitoring of landslide occurrences. (Fig.6)

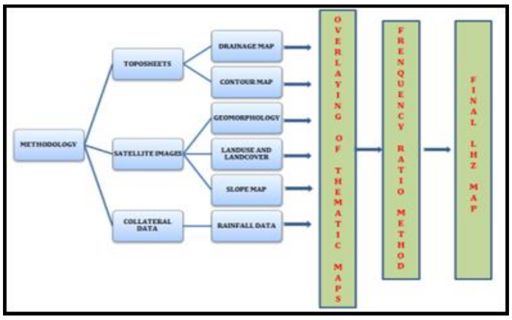

Fig.6: *Flow chart shows the methodology*

8. Results and Discussion

The developmental activities, urbanisation and change of landuse during past few decades has resulted in the degradation of the mountain ecosystem and one of the impacts of these anthropogenic activities is increased occurrence of landslides which affect the community. With increase in population the region is poised for expansion of the urban settlements and the damage in future is expected to increase. The best way to manage this hazard is to identify safe zones for human settlements.

The landslides have become major issues in all mountain ecosystems of the world. Recently the landslide frequency has gradually increased due to urbanisation and change from traditional house building techniques. Massive structures which increase the slope instability of the mountainous regions are being constructed to cope up with increase in population and to tap the tourism potential. In the India, the landslides are predominately known in three major areas viz, Himalayas, Western Ghats of Maharashtra and Nilgiri mountains. While, the Himalayan landslides are convincingly argued to be related to the active tectonic movements as well as rainfall, the landslides of Maharashtra is thought to be due to toe erosion, slope wash and fall back of the rock mass from the top (Nagarajan et al., 1998), which is also true in the case of the other parts of Peninsular India. The landslides in Nilgiri are due to extensive deforestation, direct entry of rainwater in to the sub soil system leading to the increase of the pore pressure (Seshagiri et.al. 1982).

Present study indicated that the need based research to investigate the landslides and examine their cause and distribution and to classify the region into five zones with different landslide susceptibilities. Frequency ratio method was used and these maps were validated adopting suitable methods. Landslide hazard Zones (Fig.7) were demarcated using the relationship between the landslides and the physical and environmental conditions of the terrain. Among the various causative factors used, aspect, drainage density, distance to drainage, geomorphology,landuse and soil have greater influence on landslide susceptibility. Slope though is the main cause of landslides decreases the validation as the frequency ratios do not show progressive variation and areas with very low, high and very high slopes have lesser probability of landslides with values less than 1. Based on the influencing causative factors it is clear that type of soil, the geomorphic setup and drainage density which alters the percolation of rainwater as well as the under mining by streams are the main causes of the slope instability.

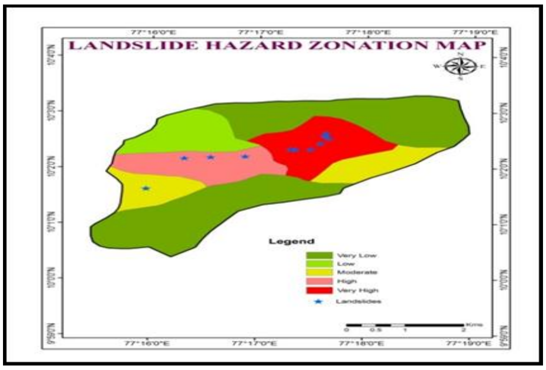

Fig.7: *Landslide Hazard Zonation map*

The LHZ shows that the north western and south eastern parts of the area are dominated by very low to moderate landslide susceptibility zones and very high and high landslide susceptibility zones are more in the southern central and northeast parts of the study area (Tab.I).

Table 1 *Shows the percentage of Landslides area and density of the LHZ*

Sl. No	Landslide Susceptibility Classes	LS	LS %	Pixels domain	Pixel %	FR
1	Very Low	1	9.09	4728	12.33	0.74
2	Low	1	9.09	5287	13.78	0.66
3	Moderate	2	18.18	5822	15.18	1.19
4	High	3	27.27	5953	15.52	1.76
5	Very High	4	36.36	16565	43.19	0.84
	Total of High & Very High	**7**	**63.64**	**11240**	**58.71**	**2.60**

8. Conclusion

The study has attempted to document the causes and effects of landslide process in Bodimettu and evolve a landslide susceptibility map which is a major step for attempting comprehensive hazard management. Frequency Ratio Method (FRM) has been used for preparing the landslide susceptibility map for the study area. The study has brought out very comprehensive methodology for preparing Landslide hazard zonation mapping in which six causative factors were used and the care was also taken to prepare a digital database very for the terrain systems and its corresponding sub variables, especially the landslide inventory map prepared for the study will be a valuable data which can be used in future. The landslide hazard zonation map prepared will be helpful to the community and disaster management authorities in mitigation of the hazard.

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