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Landslide Susceptibility Mapping and Assessment of Ketti Micro Watershed in Nilgiris District using Remote Sensing and Gis Techniques

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Abstract : The GIS and Remote sensing technologies have been useful in the field of mapping in recent days. It is possible to integrate spatial data's of different layers to determine the influence of various factors on landslide incidences. Based on the parameters such as slope, geomorphology, lineament, aspect, and present land use and soil thickness various thematic maps were prepared. By assessing proper ranks and weights the final landslide susceptible map was prepared. These maps were validated during field study.
Key words : Landslide susceptibility mapping, Ketti micro water shed, Nilgiris district, slope, geomorphology, lineament, aspect, present land use and soil thickness.

Introduction

Landslide is a regularly occurring activity in the Nilgiri district of Tamil Nadu state, India because of high intensity of rainfall. Landslides occur both in remote, unpopulated as well as in the populated areas. Most of the landslides occur in the places where deforestation, plantation, urbanization and shifting cultivation take place. In such places, more rain water may infiltrate into various soil layers and lead to landslides. As site specific study related to landslides, Landslide susceptibility assessment (LSA) was done for Ketti micro- water shed, using remote sensing and GIS techniques. Various thematic maps based on the data and field study with GIS application the present land use map, drainage map, slope map, soil map, elevation and contour maps of Ketti micro watershed were prepared.

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Figure 1 Base map of Kateri watershed

Pertaining to this work was prepared from Survey of India topographic maps and satellite imageries. The prepared maps were justified in the field during field investigations. Finally all the thematic maps were integrated using GIS applications to prepare landslide susceptibility map of ketti micro watershed (Figure 1) (Nagarajan et al 1996, Anbalagan 1992, Balachandran 1996, Gao et al 2009,Ganapathy 2010).

Landslide Suceptibility Assessment

The increase of computer-based tools has been found to be useful in the hazard mapping of landslide studies. One of such significant tools is Geographic Information Systems (GIS). With help of GIS, it is possible to integrate spatial data of different layers to determine influence of the parameters on landslide incidence. Since the early 1970s, many scientists have attempted to evaluate landslide hazards and created susceptibility maps portraying their spatial distribution by applying many different GIS based methods. The results of published papers show that landslide.

Susceptibility and hazard maps have become very effective tools for planners and decision makers. Most attempts have been made to start the intensity and dimension of landslides compared with temporal frequency of slope failures. Such kind of landslide hazard assessments is expressed in the term of Landslide Susceptibility Assessment (LSA). This landslide susceptibility assessment is based on the following causative factors in ketti micro watershed. Slope, Geomorphology, Drainage, Lineament, Land use, Aspect and Lithomarge thickness (Nagarajan et al 1996, Anbalagan 1992, Balachandran 1996, Gao et al 2009,Ganapathy et al 2010) .

SLOPE

Slope is a vital factor in the analysis of landslide susceptibility mapping (LSA). As the slope increases the possibility of the occurrence of landslide increases because the shear stress of the soil increases. Dai and Lee (2002) evaluated that land movement possibility is more when the slope angle is between 35^0 and 40^0. For the present study, slope map is derived from SRTM (Shuttle Radar Topographic Mission) DEM (Digital Elevation Model) imagery. The slope class was categorized as (0-15 %)-very gentle slope, (16- 30%)-gentle slope, (31-60%)-moderate slope and (>60%) –steep (Figure 2). This micro water shed falls within moderate to steep slope category 32-60%. The study area falls within slope percentage of 45% to 63%. The area with very high slope is found to be highly susceptible to landslide and the susceptibility decreases with the decrease in slope. It is evident that steep to very steep slopes are restricted to landslides as such these areas do not contain soil, but of exposed barren rocks. Anyhow a threat of rockfall always exist in these areas (Ganapathy et al 2010) .

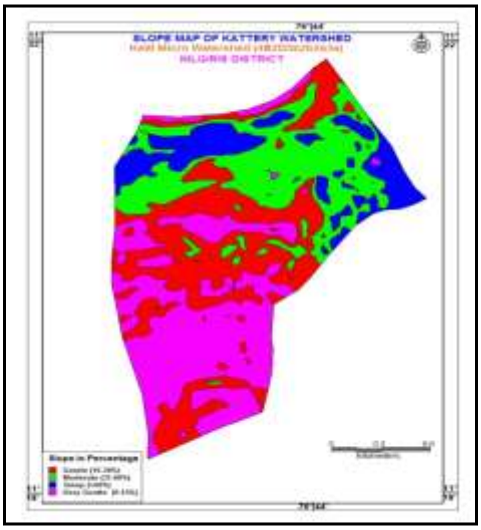

Figure 2 Slope map

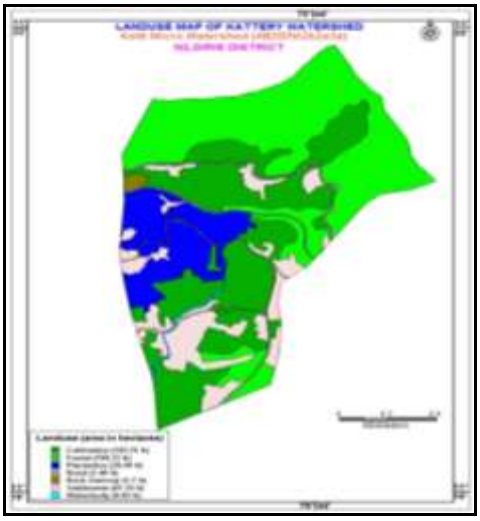

Figure 3 Present land use map

Present Land use

Changes in vegetation and cropping pattern usually impacts landslide activities. From various sources it is learnt that land use/vegetation cover of an afforested type with deep root helps to stabilize the slope. The areas with thick vegetative cover were considered to be less vulnerable to sliding with respect to the area with thin or no vegetation. The land cover map was prepared from ETM imagery. The watershed area is categorized by the dense forest, cultivation land, Estate plantation, settlement area and Road and waste lands. The areas which are very densely thick vegetated are found to be less susceptible. Areas with annual crops are more susceptible for soil erosion (Figure 3) (Ganapathy et al 2010).

Drainage

Drainage is a main cause for landslides; the coarse drainage areas are more susceptible than that of finer drainage pattern i.e, more the drainage density and less is the area susceptible to landslide. The fields with high drainage density (fine density) represent the hard rock terrain, the water flows on the surface of the terrain, resulting in less deteriorating process, however it do contribute to weathering which should not be negligible, but it is not as effective as being contributed by less drainage density. In coarse drainage patterns, the water infiltrates into the formation than to flow on the surface depending on the nature of the rock below it. The rate of infiltration is more than the rate of runoff, as a result vertical weathering is pronounced resulting in turns in the accumulation of material that is responsible for the occurrence of landslide. Continuous rainfall increases infiltration and creates a saturated soil to reduce shear strength thus leading to slope failure. Besides the presence of water in the soil or rock material the overall mass of the slope which increases the shear forces causing the slope to be less stable (Kanungo et al 2009). The drainage map was extracted from DEM in 1:50000 scales, the nature of drainage are coarsely distributed in the region (Figure 4 & 5) (Ganapathy et al 2010).

Figure 4 Drainage Map

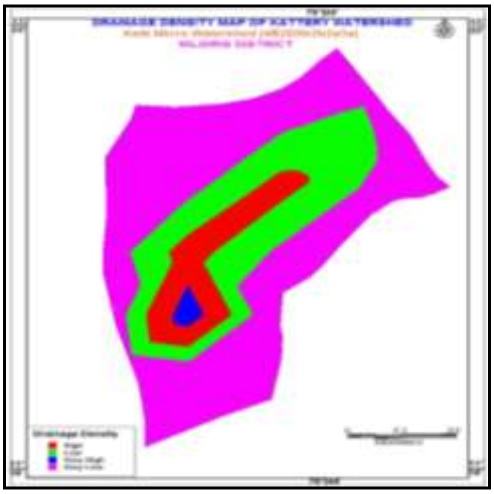

Figure 5 Drainage density map

Integration of GIS Analysis

The themes have been assigned rank and weights according to its susceptibility to landslide existence. All maps have been integrated and overlaid to arrive at final landslide susceptible map of ketti micro watershed. Susceptibility index is derived from composite weight of all the factors, which is the sum of the product of rank and weight of each overlaid theme (Rajakumar and Sanjeevi, 2007) (Figure 6 & 7) (Ganapathy et al 2010).

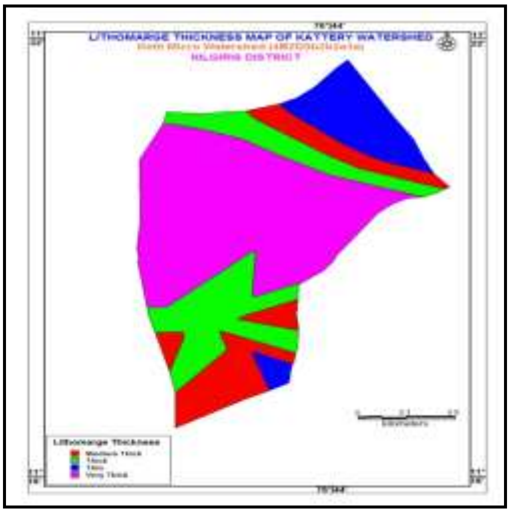

Figure 6 Lithomarge thickness

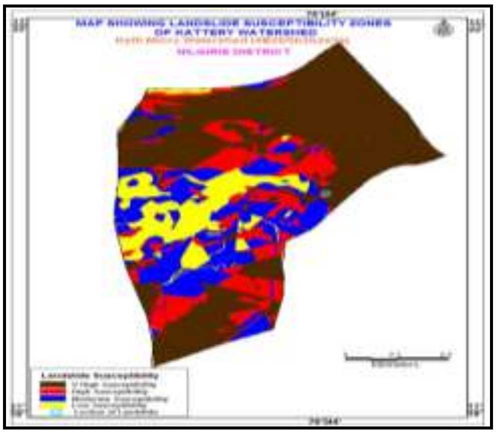

Figure 7 Landslide susceptibility

Assesment

Valuation of the landslide susceptibility map has been validated in comparison with field investigations of locations of previous major landslides within the study area. For validation of the prepared map, the past landslides occurrence data from GSI (pub no:57, 1982) was taken. There is good correlation between areas defined as highly susceptible and moderately susceptible zones and the known landslides. The study area comes under highly landslide susceptible zone (Table1 & Figure 10) (Ganapathy et al 2010).

6.2.1.1 Analysis of the data to demarcate areas susceptible to landslides

6.2.1.2 Poisson distribution

The Poisson's distribution curve is shown below (Figure 8).

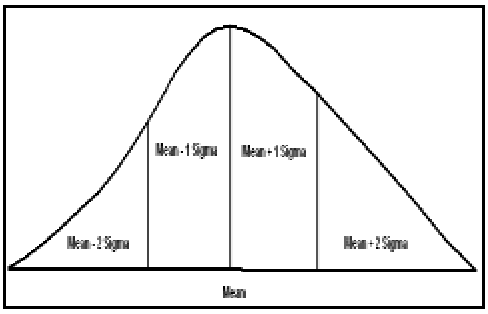

Figure 8 Poisson distribution

Statistical details of the analysis made:

The statistical details of analysis made for assessment of landslide susceptibility zone (Figure 9).

Mean (μ) – 247
Standard Deviation (σ) – 40
Classification
Very High Susceptibility – (μ + 2 σ) = > 327
High Susceptibility – (μ + 1 σ) = 287 - 327
Moderate Susceptibility – (μ - 1 σ) = 207 - 287
Low Susceptibility – (μ - 2 σ) = < 207

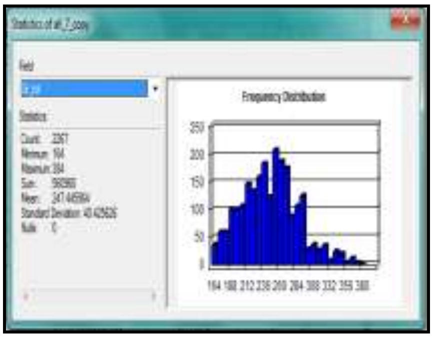

Figure 9 Frequency distribution

Table 1 Criterion table to demarcate Landslide susceptibility zones in Ketti Micro watershed

Sl. No.	**Theme**	**Classes**	**Rank**	**Weight**
1	Land use	Settlements, Cultivation	4	
		Rock outcrop	3	
		Plantation, Road	2	8
		Water bodies, Forest	1	
2	Slope in %	>60% (Steep)	4	
		31-60% (Moderate)	3	
		16-30% (Gentle)	2	30
		0-15% (Very Gentle)	1	
3	Aspect in Direction	South	4	
		Southeast, Southwest	3	
		Northeast, Northwest	2	8
		West	1	
4	Drainage Density (Length of drainage in km. per half a square km.)	0.1-0.5 (Low)	4	
		0.6-0.8 (Medium)	3	
		0.9-1.2 (Moderate)	2	14
		1.3-1.5 (High)	1	
5	Lithomarge Thickness in meters.	7 (Very Thick)	4	
		6 (Thick)	3	
		5 (Medium Thick)	2	26
		3, 4 (Thin)	1	
6	Geomorphology	Denudational Hills	4	
		Erosional Valley	3	
			2	9
			1	
7	Lineament Density	High (0.4-0.7)	4	
		Moderate (0.3)	3	
		Medium (0.2)	2	5
		Low (0.1)	1	
			Total	**100**

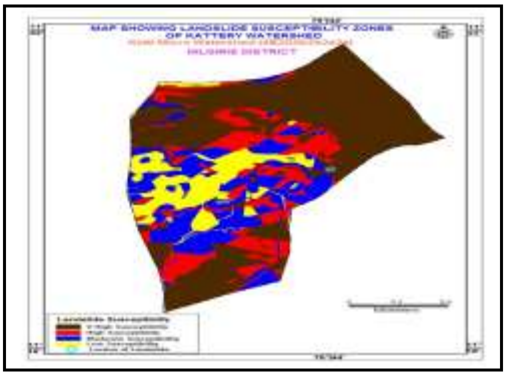

Figure 10 Landslide susceptibility Map

Conclusion

Landslide susceptible assessment was done using GIS and remote sensing applications. In which the north, north eastern part and north western part of ketti micro watershed is susceptible for landslides. It was validated in field studies that the soil thicknesses in these areas are high. Various factors such as slope, present land use, geomorphology, drainage, lineament, aspect and soil thickness were studied to arrive a valid landslide susceptibility assessment map. Proper ranks and weights were given to the above factors to evaluate the landslide assessment map. On integration of the above maps a landslide susceptibility map was generated. The entire study was based on the findings from this map.

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