ORIGINAL RESEARCH PAPER

Volume-6 | Issue-11 | November-2017 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 78.46

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

LANDSLIDE HAZARD ZONATION AND VALIDATION IN THE HILLY TERRAINS OF NILGIRIS DISTRICT USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

Engineering

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ABSTRACT

Landslides are defined by professionals like Engineers and Geologists in a unique and different way. The important factors responsible for the landslides area were assigned numerical values or ranks on a 1 to 5 scale in order of importance. Weights were assigned to the classes of the factors on a scale of 1- 100 percent influence. All the thematic maps were ranked before overlaying. The Landslide Hazard Zonation map was determined for different categories of the thematic layers on the basis of the estimated significance in causing instability. In the present study, weighted indexing method has been used to demarcate the landslide hazard zones. The classes with higher values indicate the Most Hazardous zones, followed by More Hazardous zones, followed by Moderately Hazardous zones and Less Hazardous zones and Very less Hazardous zones. Validation was done by the frequency ratio of the each of the factors slope, drainage density, soil, Lithology, geomorphology and land use/ land cover for landslide hazard zonation with the percentage occurrences of landslides

KEYWORDS

Landslides, ranking, weightages, hazard zonation, frequency ratio

1. Introduction

Landslide can be described as the downslope movement of soil, rock and organic materials under the effects of gravity and also the landform that results from such movements. The term landslides can otherwise be used interchangeably with mass movements, slope failure and so on. Landslide activities are closely associated with the tectonically active regions, and are the most common natural hazards which lead to damage in the road sector and residential areas in the hilly terrains [2].

These landslides are triggered mainly by rainfall or earthquakes. The aim of such study is to use a "working methodology" in which geo-environmental parameters are analyzed to predict landslide prone areas using remotely sensed data products and geographic information system (GIS).

2. Materials And Methods

2.1. Study Area

The study area is Nilgiris district, which is located in Tamilnadu State and lies between the latitudes 11° 10° and 11° 43° N and logitudes 76° 15° to 77° 00° E and it covers 2541 km^2.

The study area falls under the Survey of India toposheets No: 58 A/6, 58 A/7, 58 A/8,58 A/10,58 A/11, 58 A/12, 58 A/14 and 58 A/15.

The land use/ land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space [4]. The Land use / Land cover plays an important role in LHZ as it controls the rate of weathering and erosion of the underlying rock formations [5]. Satellite imagery of 2014 was visually interpreted and analyzed for the variation on the image characteristics using the standard methods of visual interpretation techniques employed for the interpretation, classification and delineation of the categories based on tone, texture, pattern etc.

The methodology consisted of preparing land use/ land cover resource map from the LISS 8 data coupled with ground truth data.

The Land use / land cover of the watershed were classified using the Maximum Likelihood Classifier of the Supervised Classification method.

The signature files were prepared as shape files and used for the classification. The LU/LC map of the study area is given in the Plate 1.

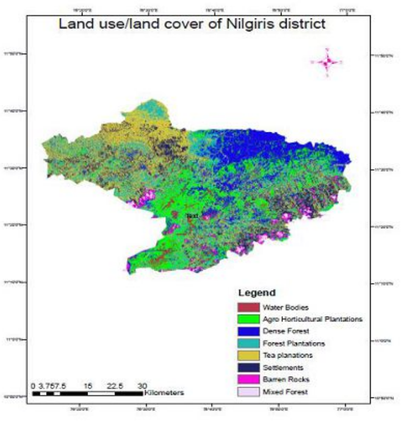

PLATE 1 : LAND USE / LAND COVER OF THE STUDY AREA

Aspect is measured in degrees from North to again NorthThe aspect can influence hydrological processes and therefore it also has an indirect bearing on weathering, vegetation and root development.

But the aspect map can also suggest which slopes are more prone to land sliding considering the spatial organization of the drainage network. Aspect degree are classified according to the aspect class as flat, north, east, south and west [3] .The aspect map was prepared from the DEM image and it indicates that the East, Southeast, South and Southwest and parts of West were highly susceptible to landslides due to direct sunlight and rainfall. Ranking is assigned to directions and formed as a thematic layer and the aspect map of the study area is given in the Plate 2.

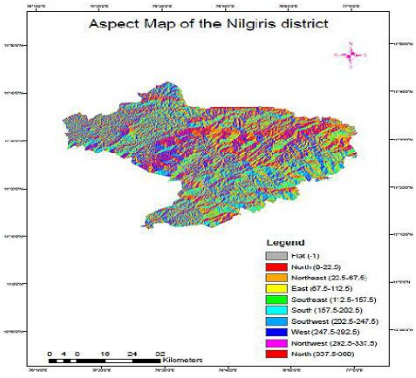

PLATE 2 : ASPECT MAP OF THE STUDY AREA

Slope is an important factor in the analysis of landslide. As the slope increases, the probability of the occurrences of landslide increases because as the slope angle increases the shear stress of the soil increases [1]. The slope map of the study area was prepared using DEM and the slope percentage was calculated. The slope is classified as slope percentages ranging from 0-10%, 10-20%, 20-30%, 30-40% and >40%. The slope percentage map of the study area is given in the Plate 3.

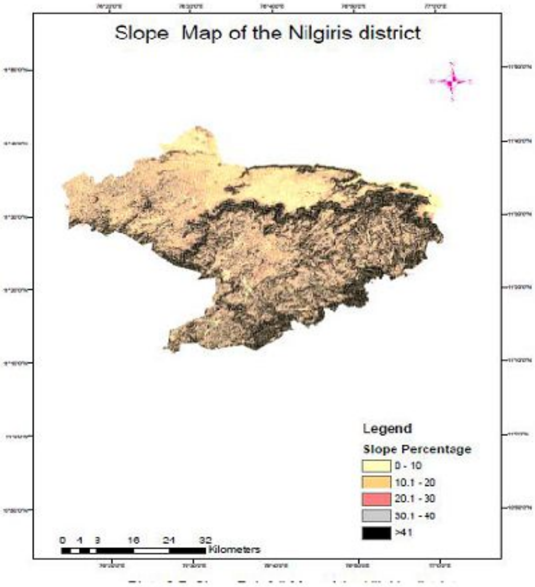

PLATE 3 : SLOPE MAP OF THE STUDY AREA

Drainage is an important ecosystem controlling the landslide as its densities denote the nature of the soil and its geotechnical properties. The drainage map was prepared using the DEM image using the ArcGIS Tool box windows. The stream orders were delineated for the channels in the study area using the Spatial Analyst tools.

The stream orders obtained was from I order to IV order. The drainage density map shows the flow of water throughout the area. Drainage density is defined as total stream length per basin area [7] The drainage density is an important factor as rain water percolates in areas with low drainage density. The drainage density of the study area has been calculated and has been classified as very low, low, medium, high and very high and is given in the map Plate 4.

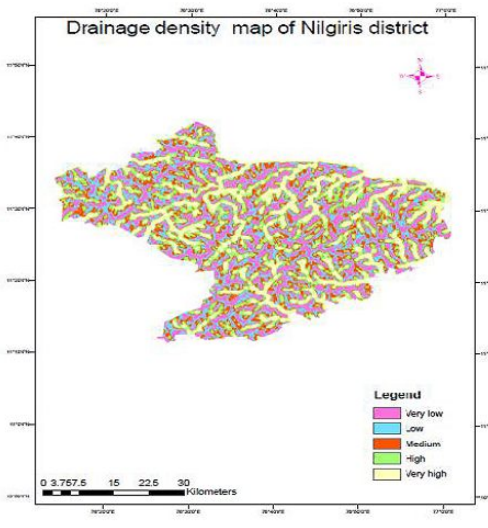

PLATE 4 : DRAINAGE DENSITY MAP OF THE STUDY AREA

Geomorphology is the scientific study of landforms and the processes that shape them. The erosional surfaces in Dodabetta, Ootacamund, Coonoor and Moyar are recorded in the district. All these erosional surfaces are capped by residual laterite [9]. The geomorphology of the study area includes Denudated hill, Hill top weathered, piedmont slope, structural hill, structural valley and valley fill. The study area is mainly underlined by Charnockite and Hornblende-Biotite-Gneisses. The geomorphology map of the study area is given in the Plate 5.

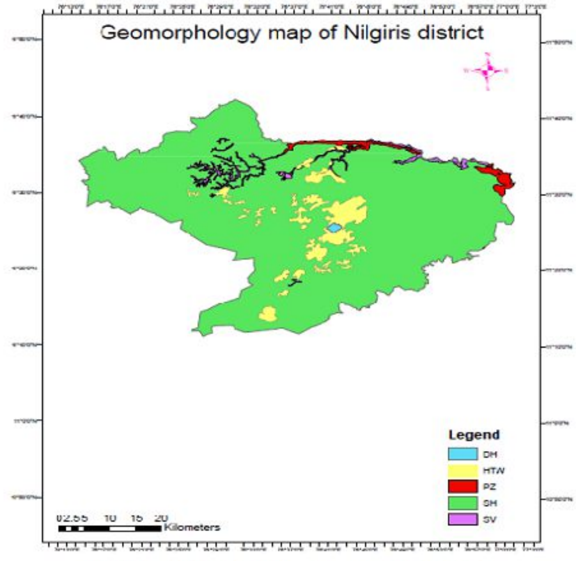

PLATE 5: GEOMORPHOLOGY OF THE STUDY AREA

The topsoil cover on a slope has an influence on landslide occurrence as observed in the field [8]. The soil map of the study area includes clay, clay loam, loam, loamy sand, sandy clay, sandy clay loam and sandy loam. The soil map of the study area is given in the Plate 6.

The Lithology in the study area is charnokite group of bedrocks, covered by the ubiquitous red laterite or lateritic soil (Lakshumanan C. et al., 2012). The Lithology map of the study area is given in the Plate 7. The Lineament density map of the study area is given in the Plate 8.

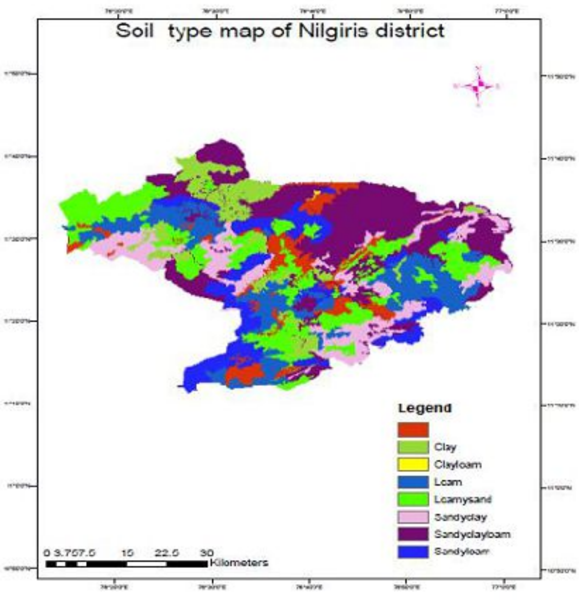

PLATE 6 : SOIL MAP OF THE STUDY AREA

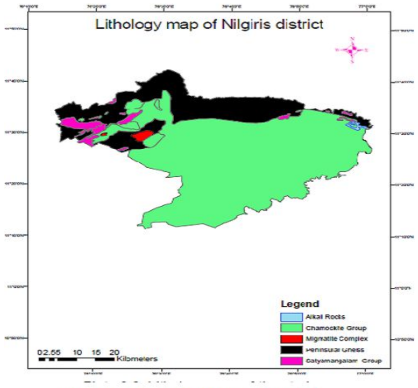

PLATE 7 : LITHOLOGY MAP OF THE STUDY AREA

Weighted overlay Tool overlays rasters based on a common measure ment scale and weights each raster according to importance. All the rasters were reclassified into integers before overlaying. All the rasters created like soil map, stream order, drainage density map, slope map, Lithology map, geomorphology map, aspect map, land use / land cover and rainfall map were ranked before overlaying. The Landslide Hazard Zonation map was determined for different categories of the thematic layers on the basis of the estimated significance in causing instability.

In the present study, weighted indexing method has been used to demarcate the landslide hazard zones. Details of the ranking and weightages of the landslide hazard zonation has been given in the table 1.

Table 1. Details of criteria, ranking and weightages for the Land Hazard Zonation Map of the study area

S.No	Criteria	Class types	Rank	Weightages %
1.	Slope	<10	1	20
		10-20	2	
		20-30	3	
		30-40	4	
		>40	5	
2.	Drainage Density	Very low	1	10
		Low	2	
		Medium	3	
		High	4	
		Very High	5	
3.	Soil	Clay	1	20
		Clayloam	1	
		Loam	3	
		Loamysand	5	
		Sandyloam	4	
		Sandyclay	3	
		Sandyclayloam	3	
4.	Lithology	Alkali Rocks	1	15
		Charnockite group	5	
		Migmatite complex	4	
		Peninsular Gniess	3	
		Sathyamangalam group	2	
5.	Geomorphology	Denudational Hills	5	5
		Hill top weathered	4	
		Piedmont slope	1	
		Structural Hill	2	
		Structural Valley	1	
		Valley fill	3	
6.	LULC	Water bodies	1	15
		Dense Forest	1	
		Agro Horticultural Plantations	3	
		Agricultural Land	3	
		Tea Plantations	3	
		Settlements	4	
		Barren	5	
		Mixed forest	2	
7	Aspect	Flat	1	5
		South	5	
		South-West	4	
		South-East	5	
		East	5	
		West	2	
		North-West	2	
		North-East	4	
		North	3	
8	Lineament density	Very Low density	5	10
		Low density	3	
		Medium density	2	
		High	1	

The classes with higher values indicate the Most Hazardous zones, followed by More Hazardous zones, followed by Moderately Hazardous zones and Less Hazardous zones and Very less Hazardous zones. In the present study, different sources were reviewed and followed for delineating the landslide hazardous zones. The resultant Landslide Hazard Zonation map of the study area is shown in the Plate 9.

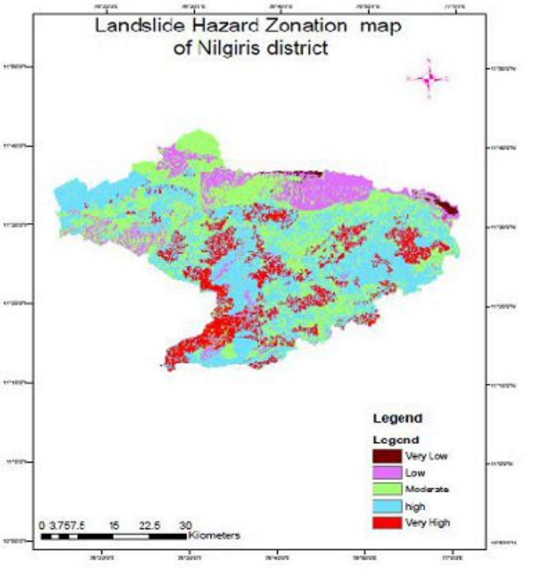

PLATE 9 : LAND HAZARD ZONATION MAP OF THE STUDY AREA

The flow chart of the procedure for delineating the Landslide Hazard Zonation map has been given in the Fig 1.

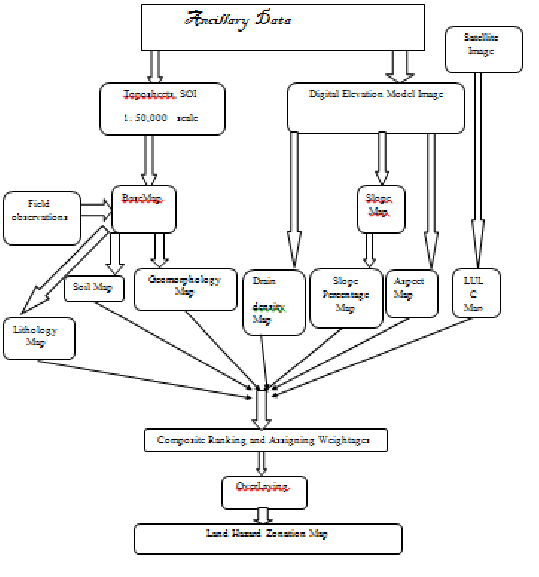

Fig 1 Flow Chart for the LHZ Map

3. Results And Discussion

The land use / land cover of the study area covers water bodies, agro horticultural plantations, dense forest, forest plantations, tea plantations, settlements, barren land and mixed forest. Improper land use such as agriculture and other plantations have a higher susceptibility to landslides. Dense forest due to the presence of deep root bindings has lower susceptibility. Therefore the ranking for barren land is given a highest rank of 5, settlements with rank 4, tea plantations and agro horticultural plantations with rank 3, forest plantations with rank 2 and dense forest with rank 1.

The landslides are most abundant in the south east facing slopes and few in the south west slope. The Eastern, South eastern, Southern aspects were given a highest rank of 5 followed by western region and North eastern region with rank 4, followed by north with rank 3 and finally North west with rank 2 and flat region with rank 1.

The slope map prepared shows that steeper slopes have greater landslide probabilities. Slopes below 20°, indicates very low probability of landslide occurrences. As the slope increases above 20°, the shear stress in the soil or any unconsolidated material increases. The slopes greater than 40 °have most chances of landslide hazard and hence has been given a rank of 5. The slope of the study area were classified into four categories such as very steep(>40) degrees, steep (30-40 degrees), moderate (20-30 degrees) and shallow (<10 degreesThe morphology of the topography is indicated by the curvature values. When the surface is upwardly convex at a pixel, a positive value is indicated. When the surface is upwardly concave at a pixel, a negative value is indicated.

A zero value is indicated when the surface is flat. The more positive or negative curvature value indicates the higher the possibility of landslide occurrences. Concave area have less landslide frequency as the concave slope contains more water and retains this water for a longer period which could lead to failure of slope triggering landslide. Convex areas have a higher landslide frequency as the convex rounded hilltop surface slopes are always exposed to repeated dilation and contraction of loose debris on an inclined surface which induces a creeping or mudslide due to heavy rainfall. In locations with convex(negative) Profile Curvature the erosion will prevail and in locations with concave (positive) curvature the deposition [10].

The drainage density is the ratio of total length of streams to the area of the drainage basin. The drainage density is an indication of the infiltration [11].. Higher the drainage density, the lower the infiltration and the surface slope is fast. The entire study area is divided into very low (<1), low (1-2), medium (2-3), high (3-4) and very high (>4) density categories. Hence a higher drainage density is given a highest rank of 5, followed by high with a rank of 4, and medium with 3, low with 2 and very low category with a rank of 1.

The geomorphology of the study area comprises of Denudated hill, hill top weathered, Piedmont slope, Structural hill, Structural valley and Valley fill. Areas near faults are most prone to landslides. Silica content is more than 70% in the acidic charnockites. Clayey horizons are found between laterites and weathered country rocks [6].

Denudational hill is given a rank of 5, followed by hill top weathered with rank 4, followed by valley fill with rank 3, followed by structural hill with 2 and finally Piedmont slope and structural valley with rank 1. Hill top weathered were given higher ranks as it is a dissected plateau with undulating surfaces.

The soil map of the study area comprises of Black and Red soil type with textures Clay, clay loam, loam, loamy sand, sandy clay, sandy clay loam and sandy loam. Sandy soils are more prone to landslides and have less water holding capacity which triggers the sliding mechanism and hence was given higher ranking.

Sandy skeletal textures are severe erosion prone and hence were given lesser ranks than sandy soils followed by clay soils as it has good water holding capacity and badly aerated. Hence clay soils were given lesser ranks. The topsoil cover on a slope has an influence on landslide [8].

The Lithology in the study area is charnokite group of bedrocks, covered by the red laterite or lateritic soil [4]. Hence Charnockite is given a higher rating of 5, followed by Migmatite with 4, followed by Peninsular Gneiss with rank 3, followed by Sathyamangalam with rank 2 and finally alkali soils with rank 1.

Based on the themes and its impact different hazard zones were delineated and classified into 5 classes namely Very Low, Low, Moderate, High and Very High Hazard zones. The results were validated using the percentage of previous number of records of landslides in the resulting zonation map and is presented in the Table 2.

Table 2. Landslide Hazard Zonation Validation

S.No	Landslide Hazard zonation classes	Percentage of previous landslides occurences	Area of Landslide Hazard zonation classes (km²)	Percentage area of Landslide Hazard zonation classes
1	Very Low	-	15.6	0.61
2	Low	14.64	304.1	11.97
3	Moderate	23.23	812.9	32.00
4	High	29.79	1078.9	42.47
5	Very high	31.31	328.8	12.94

4. Conclusion

The very high hazard zonation area accounted to 12.94 % of the total study area. The high hazard zonation area accounted to 42.47 % of the total area. The moderate hazard zonation area accounted for 32% of the total area. The low hazard zonation area accounted for 11.97% and the very low hazard zonation area accounted for only 0.61% of the total study area.

REFERENCES

[1] Evany Nithya, S., and Rajesh Prasanna, P., (2010.), An Integrated Approach with GIS and Remote Sensing Technique for Landslide Hazard Zonation , International Journal Of Geomatics And Geosciences Volume 1, No 1, 2010 ISSN 0976 – 4380.

[2] Gurugnanam, B., Suresh, M., Vinoth, M., and Kumaravel, S., (2012), High/low rainfall domain mapping using GIS at Salem district, Tamil Nadu, India, Indian Journal of Science and Technology, Vol. 3 No. 5 (May 2010) ISSN: 0974- 6846Gurugnanam et al., 2012

[3] Kuldeep Pareta., and Upasana Pareta., (2012), Landslide Modeling and Susceptibility Mapping of Giri River Watershed, Himachal Pradesh (India), International Journal of Science and Technology Volume 1 No. 2, February, 2012

[4] Lakshumanan, C., Praddep Kishore, V., Viveganandan, S., Krishnakumar, P., and Muthusankar, G, (2013), Landuse / Land cover dynamics study in Nilgiris district part of Western Ghats, Tamilnadu International Journal Of Geomatics And Geosciences Volume 2, No 3, 2012

[5] Lallianthanga, R.K., and Lalbaikmawia, F., (2013), Micro-Level Landslide Hazard Zonation of Saitual Town, Mizoram, India Using Remote Sensing and GIS Techniques, International Journal Of Engineering Sciences & Research Technology, 2531-2546, ISSN: 2277-9655

[6] Muthukumar M., (2013), GIS based Geosystem response modelling for landslide vulnerability mapping parts of Nilgiris, South India Disaster Advances Vol. 6 (7) July.

[7] Pattusamy, S., and Purusothaman, B.M., (2014), Disaster Management and mapping using Remote Sensing and GIS, Journal of Computation in Biosciences and Engineering, Volume 1/ Issue 3, ISSN:2348-7321.

[8] Sarkar, S., and Kanungo, D.P., (2004), An Intergrated Approach for Landslide Susceptibility Mapping Using Remote Sensing and GIS, Photogrammetric Engineering & Remote Sensing, Vol. 70, No. 5, May 2004, pp. 617–625.

[9] Suganthi, S., and Srinivasan.K., (2010), Digital Elevation Model Generation And Its Application In Landslide Studies Using Cartosat1, International Journal Of Geomatics And Geosciences Volume 1, No 1, 2010, ISSN 0976 – 4380.

[10] Zevenbergen, L.W. and Thorne, C.R. (1987) Quantitative analysis of land surface topography. Earth Surface Processes and Landforms.

[11]. Zubair Malik, A., Panwar, M.S., and Parmar, M. K., (2012), Landslide Hazard Zonation Of District Rudraprayag Of Garhwal Himalaya. International Journal of Current Research Vol. 4, Issue, 10, pp.237-244, October.