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# IDENTIFICATION OF LANDSLIDE-PRONE AREAS USING REMOTE SENSING TECHNIQUES IN SILLAHALLAWATERSHED, NILGIRIS DISTRICT,TAMILNADU,INDIA

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**Abstract -** In this paper, we prepare the landslide susceptibility map of the Sillahalla macro watershed in Nilgiri district Tamil Nadu at 1:50,000 scale using geospatial technology. Susceptibility analysis has involved the location of the potential slope failures, and the estimation of both landslide volume and run out distance. In the susceptible areas, landslide magnitude and frequency has been determined in order to produce the Hazard Zoning Map. Landslide data was obtained from landslide map prepared by Geotechnical Cell, Coonoor, Government of Tamil Nadu and also from Geological Survey of India, Chennai. The products derived from DEMs are contour maps (20m interval), slope maps, aspect maps, shaded relief maps, topographic map, landuse\landcover map, slope map, soil map, geology, transportation network, and relative relief map have been utilized to generate various thematic data layers in GIS environment. In order to get the landslide prone areas, the weightage should be assigned to each map layers. Depending on the threat posed by each category the Landslide Susceptibility Index, i.e.weightages was assigned. The data layers have been integrated in GIS by overlay analysis. Data handling and treatment with the GIS has allowed the performance of the landslide hazard assessment and mapping in a fast and reproducible way.

***Key Words:*** *Landslide, Remote Sensing ,GIS*

## 1. Introduction

Landslide is defined as the movement of a mass of rock debris, or earth down the slope (Cruden 1991). The term 'Landslide' encompasses events such as ground movement, rock falls, and failures of slopes, topples, slides, spreads, and flows such as debris flows, mudflows or mudslides (Varnes, 1996). Gravity acting on a steep slope is the primary reason for the landslides.

In hilly regions, landslides constitute one of the major hazards that cause losses to lives and property. Landslide analysis is a complex analysis, involving multitude of factors and it needs to be studied systematically in order to locate the areas prone for landslides. Computer-based tool namely Geographical Information System (GIS) is found to be more useful in the hazard mapping of landslides.

This study uses remote sensing and GIS tools to extract detailed geomorphic, structural, landuse, slope and drainage information in the Nilgiri area and suggests an appropriate model for landslide hazard zonation and mitigation studies. This paper is concerned with the use of Remote Sensing and GIS tools to understand the mechanisms of slides in the Nilgiri hills.

### 1.1 Study Area

The area falling under macro-watersheds with a total extent of 67 km$^2$ is selected for study as the area is affected by landslides during the years 1969 and 1970. It lies between the latitudes 11º25'0"N and 11º20'0"N, and longitudes 76º38'0"E and 76º44'0"E, and forms parts of Survey of India Toposheet Nos 58 A/11/N(Fig.1). The minimum and maximum altitude of the area selected is 1860 m and 2640 m respectively above mean sea level.

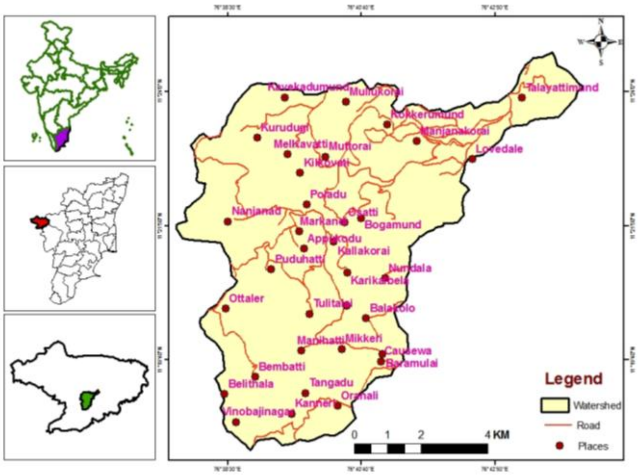


**Fig -1**: Base Map of the study area

### 1.2 Aim and Objectives

The aim of the study is to assess the landslide susceptibility of a macro-watershed and to prepare a Landslide Hazard Zonation Map. The study is carried out using GIS and Image processing techniques. The approach used is by overlay analysis of the Landslide contributors after simple statistical analysis to arrive the frequency ratio for each feature.

The base maps and thematic layers were prepared with data acquired from different sources and the following thematic layers were prepared.

## 2. Methodology

The methodology for the LS mapping can be categorised into five phases. Data collection, Preparation of digital database, Landslide Susceptibility zonation using statistical methods, validation and evaluation and layout and final reporting.

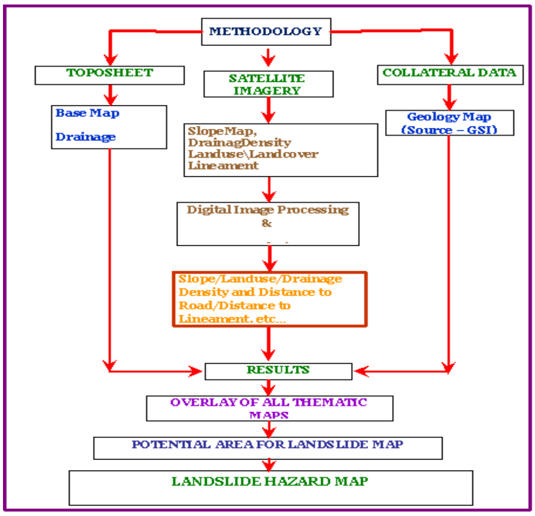


**Fig -2**: Methodology of the study area

## 3. Preparation of Thematic Maps

### i) Drainage Map

The Nilgiris is drained by hundreds of streams which belong to the Moyar and Bhavani Rivers. The drainage is part of Cauvery River basin, one of the major river basins in South India. The Bhavani River is a tributary of the Cauvery and is formed by the confluence of Bhavani and Moyar Rivers. The dominant drainage pattern is dendritic drainage pattern. Stream ordering using Strahler's method shows that Moyar and Bhavani as the confluence near Bhavani Sagar are 5th order streams and within the study area.

A drainage system that develops on a regional surface is controlled by the slope of the surface, the types, and attitudes of the underlying rocks Drainage patterns which are visible on aerial photographs and satellite images. The drainage map was prepared from the survey of India topographic sheets.

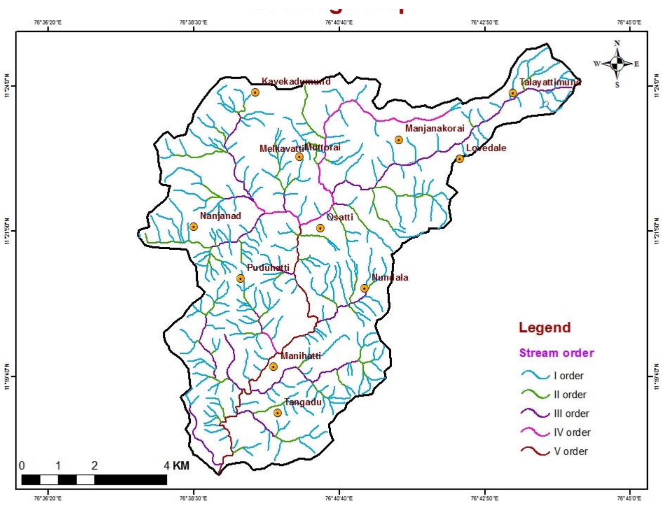


**Fig -3**: Drainage map of the study area

### ii) Contour Map

Contour map was extracted from the toposheets with the scale of 1:50,000 using the ARC GIS software. Contour Map is extracted by SRTM (Spatial Analyst) with the contour interval of 20 metres.

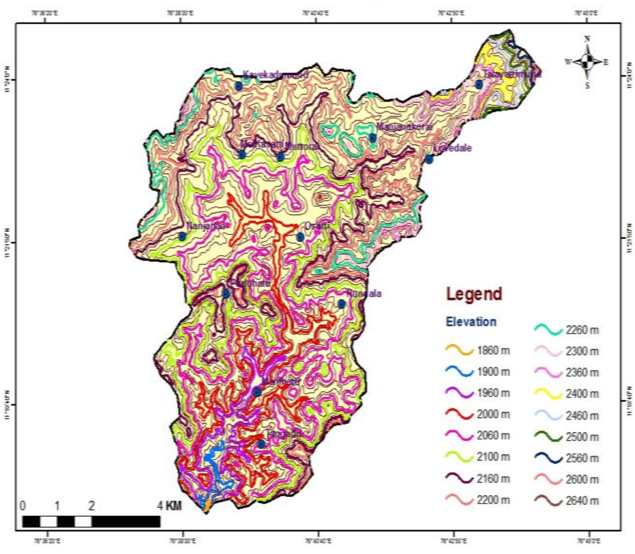


**Fig -4**: Contour map of the study area

### iii) Slope Map

If the slope is higher then there is a chance of occurrence of landslide. DEM have been used for the preparation of slope map. The pixel size of the slope map is kept as 30 m. The slope map was classified into six classes viz., 0–5°, 5–10°, 10–15°,15–20°, 20–25°, and >25°. The very low slope class 0 to 5° is selected as two slide including creep occurs in such gentle slopes. The very high slope category is selected as no slide taken as > 25° as soil cover is insignificant in such slopes and landslides do not occur. Though rock-falls can occur in very high slopes, no rock-fall is encountered in the study area.

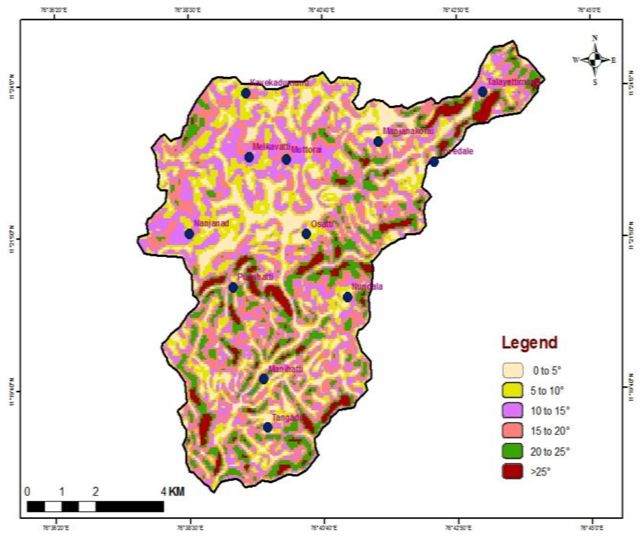


**Fig -5**: Slope map of the study area

### iv) Landuse & Landover map

Landuse & Landover map where produced by digitization of the LANDSAT MSS satellite imagery of the study. Based on the aerial photo interpretation, the general Landuse of the study area is divided into various categories like Dense forest, Forest plantation, Mixed cultivation, Out crop, Reserve land, Settlement, Tea estate, Vegetation. In the northern part of the study area, forest plantations are dominantly present whereas in the southern part is covered by the tea and coffee plantations. The urban activities result in the modification of slope due to widening of road and leveling of the terrain forming steep cut. As a result high frequency was arrived for the Vegetation where most of the road network occurs. The Vegetation is maximum with 23 landslides each out of 55 slides which is 41.82%. Mixed cultivation, Forest plantation, Tea Estate, Reserve land and Settlement rank next in the susceptibility.

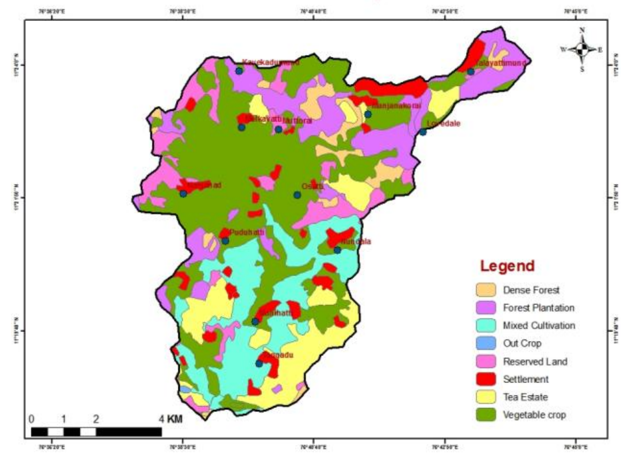


**Fig -6**: Landuse & Landover map of the study area

### v) Aspect map

Aspect is the orientation of the slope and is calculated as flat, N, NE, E, SE, S, etc., The aspect of a slope may also contribute to slope failure and has been used by several in landslide susceptibility analysis. Aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. It can be thought of as the slope direction. The values of the output raster will be the compass direction of the aspect.

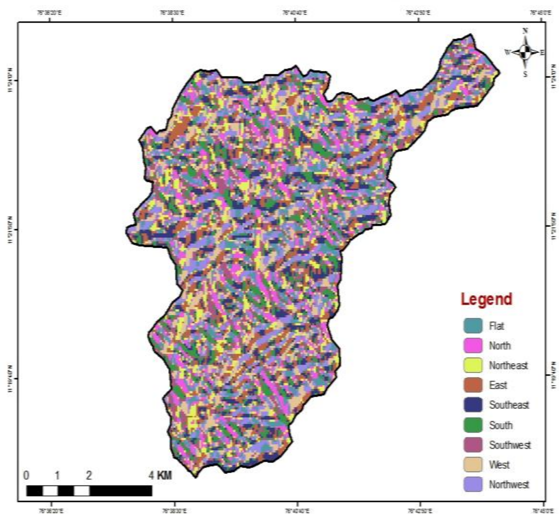


**Fig -7**: Aspect map of the study area

### vi) Geomorphology Map

Geomorphology is also an important factor which induces the landslide in the study area. It is derived from the satellite images and also from image processing techniques in order to delineate the features precisely. Geomorphology is classified into five categories viz., Hill top weathered, Hills, Moderately dissected plateau, Pediment, Plateau.

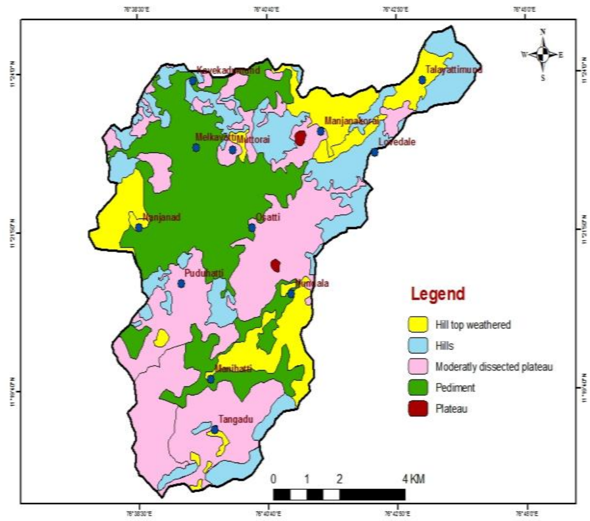


**Fig -7**: Geomorphology map of the study area

### Vii) Drainage Density Map

Drainage Density Map was calculated using the spatial analyst module of the ArcGIS software through which total length of drainages was counted per unit cell and isoclines were drawn. Drainage density is an important factor as it provides an indirect measure of groundwater conditions, which have an important role to play in landslide activity (Sarkar and Kanungo, 2004). The drainage density ranges from 0 to 8 Sqkm. The drainage density was divided into five groups according to their density values such as 0-1.5sqkm, 1.5-3sqkm, 3-.5-4sqkm, 4.5- sqkm6, 6-8sqkm aerial coverage of them. Drainage density map was prepared using the Density tool in extension Spatial Analyst of ArcGIS.

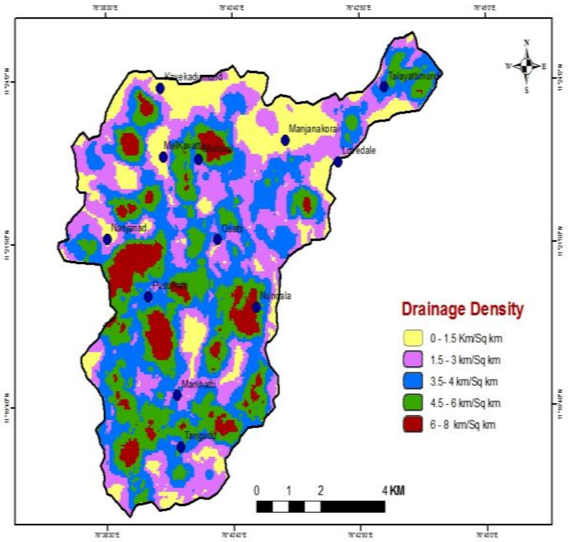


**Fig -8**: Drainage Density map of the study area

### Vii) Distance to Drainage Map

The distance to drainage layer has been categorised into 5 sub variables. Majority of landslides (90.91%) in the area have been occurred close to the stream with in a distance of 100m and 200m and 3 landslides (5.45%) have occurred with in 300m distance, 2 landlides (3.64%) have occurred with in 400m distance, no landslide has taken place beyond 500m. Hence, distance to drainage taken as basis for landslide hazard zonation .this is due to the fact that the land slides are due to the creation of steep slope due to erosion.

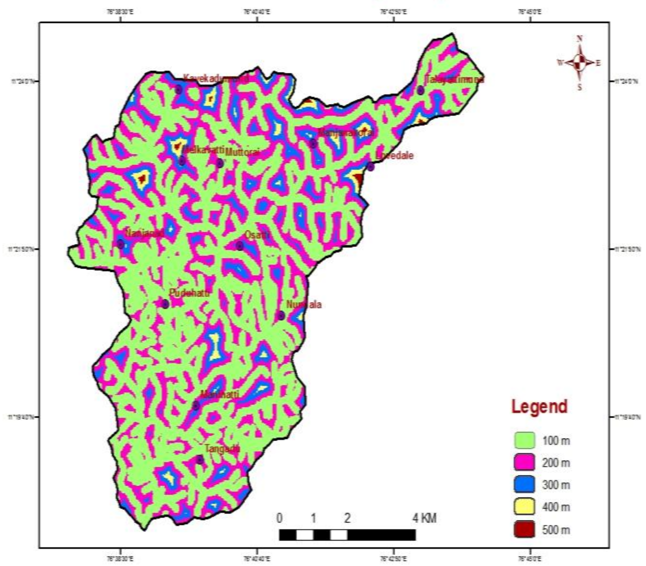


**Fig -9**: Distance to Drainage map of the study area

## 4. Result and Discussion

The present study hence, is a 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. Landslide hazard Zones 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 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.

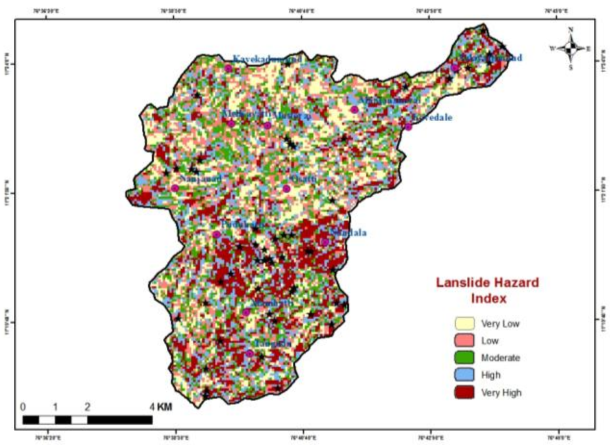


**Fig -10**: Landslide Susceptibility Map

## 5. CONCLUSIONS

The study has attempted to document the causes and effects of landslide process in Nilgiris and evolve a landslide susceptibility map which is a major step for attempting comprehensive hazard management. The study has brought out very comprehensive methodology for preparing Landslide Susceptibility Mapping in which 9 causative factors were used and the care was also taken to prepare a digital database very for the terrain systems and

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its corresponding sub variables. In particular the landslide inventory map prepared for the study will

be a valuable data which can be used in future. The landslide susceptibility map prepared will be helpful to the community and disaster management authorities in mitigation of the hazard.

Mapping in which 9 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. In particular the landslide inventory map prepared for the study will be a valuable data which can be used in future. Further, attempt has been made to document the landslide event in 2009. The landslide susceptibility map prepared will be helpful to the community and disaster management authorities in mitigation of the hazard.

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