International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-02, Issue-05, May 2015

Slope Stability Analysis for Identifying Landslide Prone Areas Using Remote Sensing and GIS Techniques in Munnar

Sujitha P R, Jayaprasad B K, Karuppasamy S

Abstract— **Landslide is a major hazard occurring in Hilly area which may cause damage to infrastructure and threaten several lives. Landslide Hazard Zonation map helps to identify the critical areas that are prone to landslide. For the preparation of landslide hazard map ten parameters were contemplated. This parameter incorporate Land use/Land cover, Slope, Aspect, Drainage Density, Lineament Density, Relative Relief, Geology, Geomorphology, Soil, Rainfall respectively. CartoSat I Stereopair of Munnar has been used to generate Digital Elevaion Model(DEM) using imagine photogrammetry suite. consequently Slope map, Aspect map, Drainage map, Relative Relief map were prepared. Lineament Density map was prepared from hillshade at various Azimuth and illumination angle. The various parameters were classified and weighed according to their importance in slope instability using Weighted Overlay Analysis. Landslide Hazard Zonation map showing four classes ranges from No Hazard to Very High Hazard region was prepared. Very high hazard zones were observed in some areas such as Munnar, Mankulam, Varayadu motta, Kolukku mala.**

Index Terms— **Cartosat I Stereopair, Digital Elevation Model, Landslide Hazard Zonation, Weighted Overlay Analysis.**

I. Introduction

Landslide is a major sliding activity of rocks or soil masses. Large-scale landslides frequently occur in steep mountain regions. Landslides are the common problem that occurs in the hilly region of Kerala. Several areas in Kerala such as Idukki district and Northern district are prone to landslides. The most common type of landslide that occurred in Kerala are debris flow, debris slide, debris avalanche and rock fall. Computer-based tool namely Geographical Information System (GIS) is found to be more useful in the hazard mapping of landslide. Carson and Kirby (1972) classified the landslides based on Velocity (High to Slow) and Water content (Dry to Wet). The classification of landslide by Carson and Kirby is shown in fig 1

Manuscript received May 16, 2015
Sujitha P R, Department of Civil Engineering, Regional Centre of Anna University, Tirunelveli, India
Jayaprasad B K, Scientist-E, National Centre for Earth Science Studies, Trivandrum, India
Karuppasamy S, Assistant Proffesor, Department of Civil Engineering, Regional Centre of Anna University, Tirunelveli, India

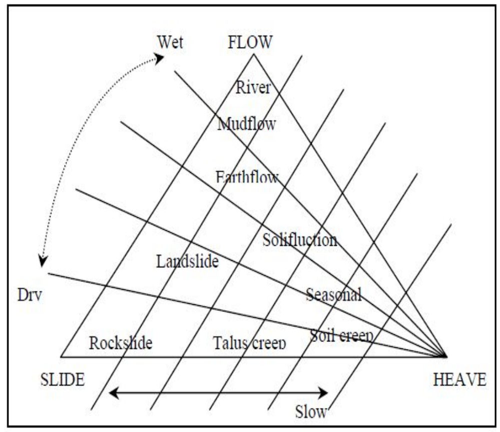

Fig 1: Classification of Landslide by Carson and Kirby (1972)

A. Objective

- To generate DEM from cartosat I stereopair using imagine photogrammetry suite.
- To generate various thematic maps for identifying landslide prone areas
- To generate a Landslide Hazard Zonation map using weighted overlay analysis

B. Need for the Study

- Landslides are one of the destructive geological processes which cause not only enormous damage to roads, bridges, and houses but also lead to loss of life. Hence, there is a need for identification of potential landslide areas.
- Field work of identifying landslide prone area by conventional method is expensive and time consuming.

II. Study Area

Munnar (Fig 2) is a panchayat and hill station situated in Idukki district of southwestern Indian state of Kerala. It is situated at around 1600m(5200 ft) above sea level in the western ghats range of mountains. It lies on 10º04'N latitude and 77º04'E longitude. The name Munnar is trusted to mean "three rivers", referring to its location at the junction of the Madhurapuzha, kundaly and Nallathanni rivers. It is located on the kannan devan hills village in Devikulam taluk and is the largest panchayat in Idukki district covering an area of nearly 557 sq.km.

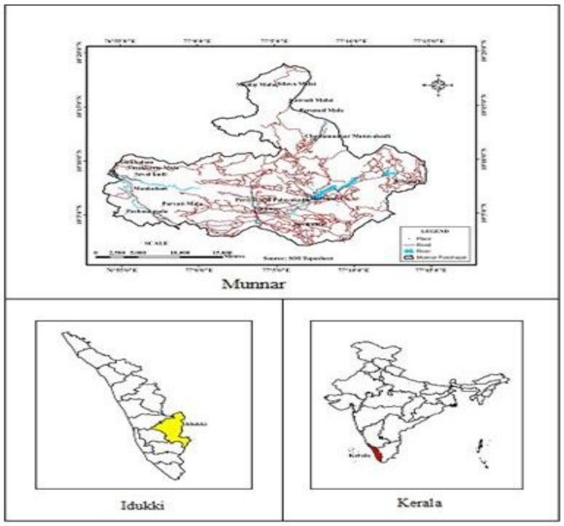

Fig 2: Study Area

III. Methodology

The Cartosat I Stereopair of Munnar was the main source of DEM from which the various thematic maps had been prepared. The methodology flowchart is shown in fig 3.

A. Generation of DEM using Cartosat I Stereopair

Inorder to generate DEM, the cartosat I stereopair having two bands were loaded in imagine photogrammetry. The loaded images would not have interior and exterior orientation. Therefore the Rational Polynomial Coefficient(RPC) file had been included. Auto tie points had been generated using a auto tie point tool. The Root Mean Square(RMS) error had been checked. Finally, DEM had been extracted.

B. Preparation of Thematic Maps

Land use/Land cover map was prepared from LISS III (2011) image using supervised classification in ErdasImagine2015 software.

The slope map and aspect map were prepared from Cartosat-I DEM using ArcGIS 10.3 software.

Drainage map was prepared from DEM using ArcHydro tool and the Drainage Density map was generated from drainage using the kernel density tool in ArcGIS 10.3 software.

Lineament map was generated from DEM at various Azimuth angle(0º – 360º at 45º interval) and illumination angle (15º and 34º). Lineament Density map was prepared from lineament map using kernel density tool in ArcGIS 10.3 software.

Inorder to prepare the relative relief map, raster calculator had been used to subtract minimum DEM from maximum DEM, whereas minimum DEM and maximum DEM were generated using focal statistics tool in ArcGIS 10.3 software.

Lithology, geomorphology, soil data were collected from National Center for Earth Science Studies(NCESS), Kerala.

C. Preparation of Landslide Hazard Zonation Map

Landslide hazard zonation map was prepared by integrating all the thematic maps. Weighted overlay analysis is a tool in ArcGIS 10.3 software that has been used to include several raster layer and helps to assign weightage for each layer. Thus, the weightage had been assigned to each layer using weighted overlay tool and the landslide hazard zonation map had been generated.

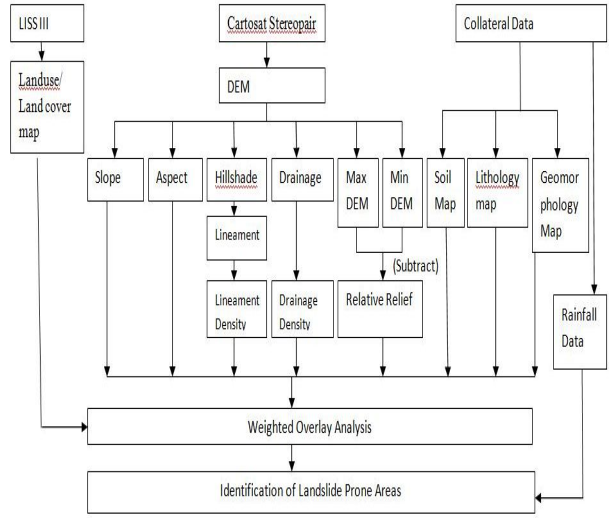

Fig 3: Flowchart of Methodology

IV. Results And Discussion

Inorder to generate Landslide Hazard Zonation map several thematic maps such as Land use/Land cover, Slope, Aspect, Drainage density, Lineament Density, Relative Relief, Lithology, Geomorphology, Soil were given as input.

A. Land use/Land cover

The Land use/Land cover influence a control over landslides. The land use/land cover map of munnar is shown in fig 4. The study area covers 7.78Sq.km Water body, 119.91Sq.km Eucalyptus plantation, 142.19Sq.km Dense Forest, 115.3Sq.km Open Scrub, 158.47Sq.km Tea plantation, 13.39Sq.km Settlement.

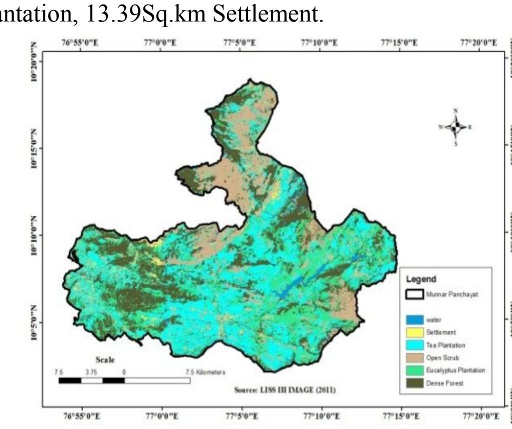

Fig 4: Land use/Land cover map

B. Slope

Slope is a key factor for identifying the Landslide prone areas. As the slope increases, the shear stress of the soil increases. Consequently, the probability of occurrence of landslide also increases. The slope of the study area had been classified into five categories such as <6º, 6º – 15º, 15º – 24º, 24º – 37º, 37º – 82º. The slope map that had been generated from DEM is shown in fig 5.

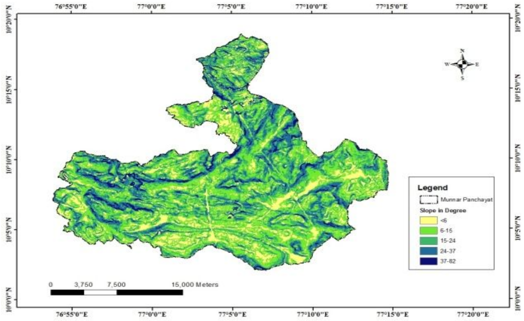

Fig 5: Slope Map

C. *Aspect*

Aspect may be defined as a compass direction that a slope faces. It can have a strong impact on temperature. The slope aspect reflect the vegetation and moisture retention , which in turn may disturb soil strength and sensitivity to landslides. The aspect map of the study area showing the cardinal and intermediate cardinal direction that a slope faces is shown in fig 6.

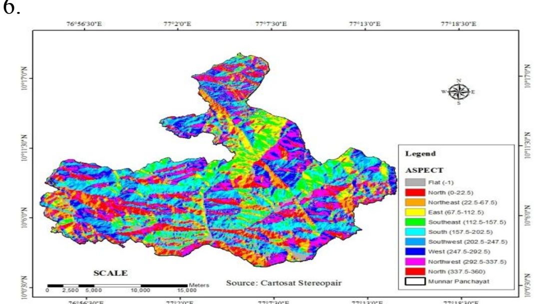

Fig 6: Aspect Map

D. *Drainage Density*

The probability of occurrence of landslide increases with increase in distance from the drainage line. The Drainage Density was classified into four categories i.e., Low density, Moderate density, High density, Very High density. The Drainage Density map is shown in fig 7.

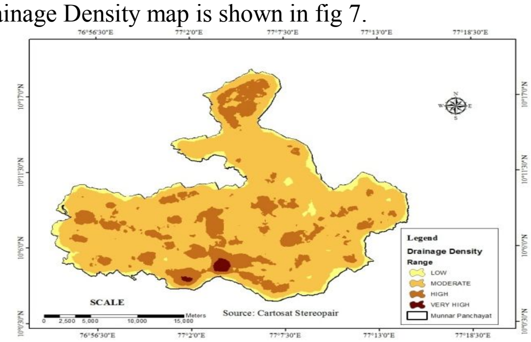

Fig 7: Drainage Density Map

E. *Lineament Density*

A lineament may be defined as a linear feature in a landscape which is an expression of an underlying geological structure such as fault. Water flows through the cracks and the soil over the lineament would slide and hence this may provoke the landslide. Lineament map of the study area is shown in fig 8.

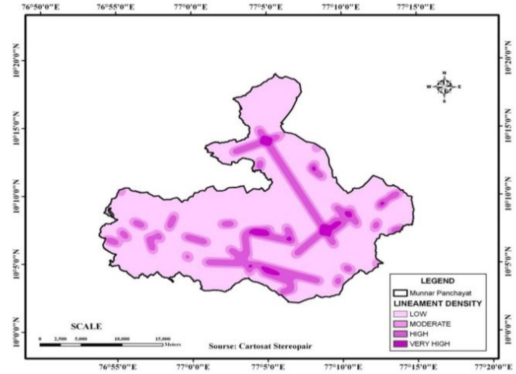

Fig 8: Lineament Density map

F. *Relative Relief*

Relative relief is the difference between the summit level (highest altitude) and the base level (lowest altitude) for a given area. As the relative relief is high, the probability of occurrence of landslide is also high. Relative Relief map that had been prepared from DEM is shown in fig 9.

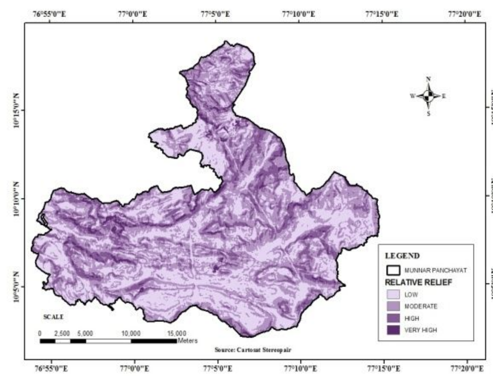

Fig 9: Relative Relief Map

G. *Lithology*

Lithology basically involves the texture, composition, degree of weathering, as well as other details that influence the physico-chemical and engineering behaviours such as shear strength, permeability, etc. of the rocks and soils. These characteristics in turn affect the slope stability. The types of rock present in the study area are Granite, Hornblende Gneiss and Pink Granite Gneiss as shown in fig 10.

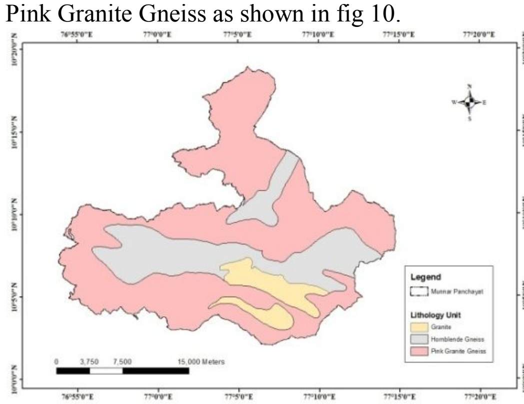

Fig 10: Lithology Map

H. Geomorphology

Geomorphology represents the structure of the terrain. The study area comprises of Denundational hills, Dissected middle plateau, Valley, Valley(Denundational), Water body mask. The geomorphology of study area is shown in fig 11.

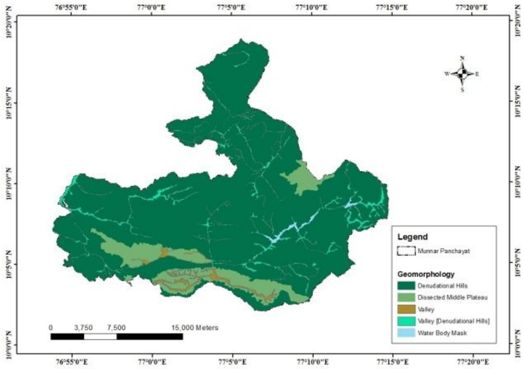

Fig 11: Geomorphology Map

I. Soil

The major type of soil that covers the study area is clay. The study area comprises of clay, sandy clay, loamy clay, silty clay, loamy sand, sand and rocky categories. The soil map is shown in fig 12.

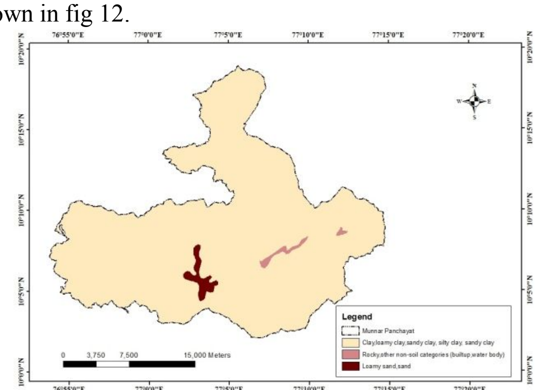

Fig 12: Soil Map

J. Rainfall

Intense rainfall has repeatedly proved capable to trigger widespread soil slips and debris flow where morphology, hydrology and soil cover are favorable to soil instability. The annual rainfall and monthly rainfall in mm is shown in fig 14.

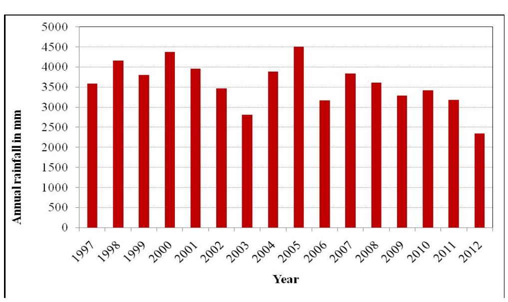

Fig 13.a: Rainfall Hyetograph (Annual)

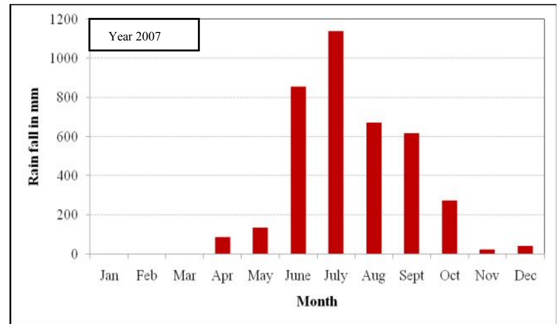

Fig 13.b: Rainfall Hyetograph (monthly)

K. Landslide Hazard Zonation

Landslide Hazard Zonation map was generated by integrating all the parameters and was categorized into 4 types such as no hazard zone, low hazard zone, moderate hazard zone, high hazard zone. The landslide hazard zonation map is shown in fig 14.

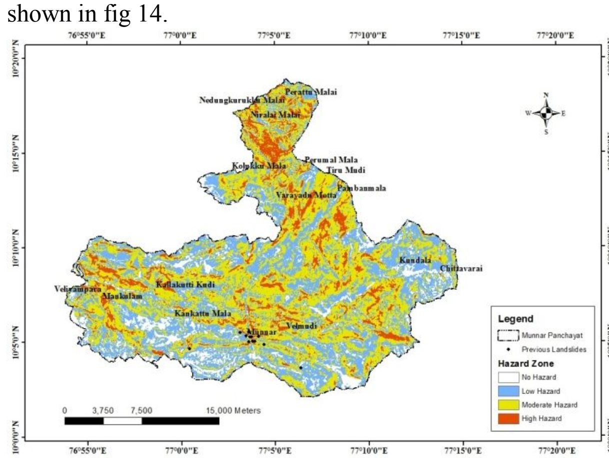

Fig 14: Landslide Hazard Zonation Map

CONCLUSION

The area that has been categorized under high hazard zone are Munnar, Mankulam, Varayadu motta, Kolukku mala. In these areas the slope, drainage density, lineament density were high and the hazard zones comprises of soil such as sand and clay. It has been witnessed that the landslides occur in munnar was due to incessant rainfall. The major hazard took place when an average rainfall level reached 4500mm. As the rain gauge station data was not available, the average rainfall was used for analysis. The average rainfall of munnar is 2470mm. When an incessant/heavy rainfall occurs, the probability of occurrence of landslide is maximum in the identified hazard zone. This study may be used to evacuate the people in hazard zone when the rainfall exceeds the threshold limit.

REFERENCE

[1] Biswajeet pradhan, Shattri mansor, Saied pirasteh and Manfred f. Buchroithner, "Landslide hazard and risk analyses at a landslide prone catchment area using statistical based geospatial model", International Journal of Remote Sensing, vol. 32, No. 14, July 2011, , pp 4075-4087.

[2] Biswajeet pradhan, Shattri mansor, Saro lee, Manfred f. Buchroithner, "Application Of A Data Mining Model For Landslide Hazard Mapping", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XXXVII. Part B8, 2008, pp 187-196.
[3] D. P. Kanungo, M. K. Arora, S. Sarkar , R. P. Gupta, "Landslide Susceptibility Zonation (LSZ) Mapping - A Review", Journal of South Asia Disaster Studies, vol.2, No.1, June 2009, pp 82-105.
[4] H.R. Pourghasemi, H.R. Moradi, M. Mohammadi, B. Pradhan, R.Mostafazadeh, A. Goli Jirandeh, "Landslide Hazard Assessment Using Remote Sensing Data, GIS and Weights-of-evidence Model (South of Golestan Province, Iran)", Asia Pacific Conference on Environmental Science and Technology, Advances in Biomedical Engineering, vol.6, 2012, pp 30-36.
[5] R.K.Lallianthanga, Z.D.Laltanpuia, Robert Lalchhanhima Sailo, "Landslide Hazard Zonation Of Lawngtlai Town, Mizoram, India Using High Resolution Satellite Data", International Journal Of Engineering And Science vol. 3, Issue 6, August 2013, pp 36-46.
[6] S. Sarkar and D.P. Kanungo, "An Integrated Approach for Landslide Susceptibility Mapping Using Remote Sensing and GIS", Photogrammetric Engineering & Remote Sensing, vol. 70, No. 5, May 2004, pp 612-625.
[7] S.S. Ramakrishnan, V.Sanjeevi Kumar, M.G.S.M. Zaffar Sadiq, M. Arulraj and K. Venugopal, "Landslide Disaster Management and Planning.A GIS based Approach", Indian Cartographers, 2002, pp 192-195.
[8] Saro Lee and Biswajeet Pradhan., "Probabilistic landslide hazards and risk mapping on Penang Island, Malaysia", J. Earth Syst. Sci. 115, No. 6., Decembe 2006, pp 661-672.