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RESEARCH ARTICLE

REMOTE SENSING AND GIS BASED LANDSLIDE SUSCEPTIBILITY STUDIES IN PARTS OF KOVAI AND NILGIRIS DISTRICT, SOUTH INDIA

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A B S T R A C T

Aim of the present study is to locate the landslide susceptibility zone with help of AHP method. Detailed Rainfall, Drainage and Slope assessment were carried out to assess the landslide hazard zonation. This objective is to map rainfall-induced and various other parameters with the help of landslide hazards over a region by using GIS. From this study, it is interpreted that the distribution of landslides is largely governed by a combination of geo-environmental conditions, such as geology, soil type, annual average rainfall, slope, land use/land cover, drainage density, lineament density, geomorphology and annual average water level. All the above parameters provide certain clues for the preparation of Landslide Vulnerable and Hazard Zonation map. In order to get all these information's unified, it is essential to integrate these data with appropriate factor. Therefore, numerically this information is integrated through the application of GIS. Overall, thematic maps were assessed for the landslide vulnerability and hazards zonation mapping. The results were related with the locations in which major landslides had occurred in the study area. There is good correlation between areas defined as vulnerable and hazardous, and the existing landslides were noticed. There were several landslides in the study area which coincided with the vulnerable and hazard zones.

INTRODUCTION

Recently, a number of attempts have been made to quantify landslide risk (e.g., Kong, 2002; Catani *et al*., 2005; Zezere *et al*., 2007; Remondo *et al*., 2008). Researchers have expressed risk in different ways such as loss over a specified time period or annual loss, depending on the quality of landslide information, the scale of the study, and the aim of the analysis. However, if the analysis is meant for defining risk reduction strategies then it is recommended to express risk as annual loss in order to be able to carry out a quantitative cost-benefit analysis, and also because quantitative risk acceptance criteria for loss of life are usually expressed in per annum terms (Fell *et al*., 2008). In most case studies, risks are quantified for elements at risk located in the landslide initiation areas, whereas much less work has been done to assess risk by incorporating run-out distance of a landslide (e.g., Bell and Glade, 2004).

If an area has a potential for hazardous debris flows then the estimation of run-out distance is essential in order to evaluate the actual risk. Several empirical methods such as the mass-change method (Cannon and Savage, 1988), the angle of reach method (Hungr *et al*., 2005), and process based methods (Remaitre *et al*., 2005) are suggested for run-out calculation. The question remains, however, how to incorporate these for the many possible landslide initiation areas in a quantitative susceptibility map with many mapping units having different spatial probabilities (van Westen *et al*., 2006). Process-based methods have been used to demarcate landslide hazard areas but they experience serious problems with parameterization, which makes their application problematic over larger areas, especially in a heterogeneous terrain setting (Kuriakose *et al*., 2009). One way to include run-out distance in risk analysis, over a large area, is to use empirical relationships such as the identification of all hazardous zones likely to affect the elements at risk that are located down slope of the landslide initiation areas, followed by a loss estimate for each element separately.

The GIS-based data analysis procedures provide ways and means to integrate diverse spatial data (e.g. Bonham-Carter, 1994; Carrara and Guzzetti, 1995; DeMers, 2000; Gupta, 2003). The advanced GIS computational tools offer numerous advantages in multi-geodata handling, as is evident from various geoenvironmental studies. However, these studies lack spatial level comparison of GIS derived maps. The focus of this paper is on comparative evaluation of spatial maps through different approaches.

Study Area

Landslide studies were an executed in part of Kovai and Nilgirisdistricts of the Western Ghatsregion in Tamilnadu. Study area map prepared from Survey of India (SOI)

Toposheets No. 58 A/11 and 15 published by the Survey of India in 1: 50,000 scales. The total area an about 417.17 km^2. The highway is an extension of NH-67 connecting the states Tamil Nadu and Karnataka. The study area lies in between 76°40'29.16" to 76°56'25.10 E longitudes and 11°25'18.256'' to 11°17'32.26" N latitudes. The elevation ranges between 280 m and 2620 m above MSL. (Fig.1)

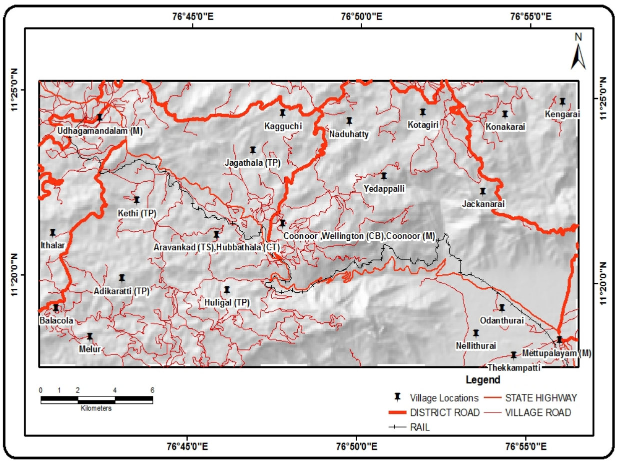

Figure 1 Study area map

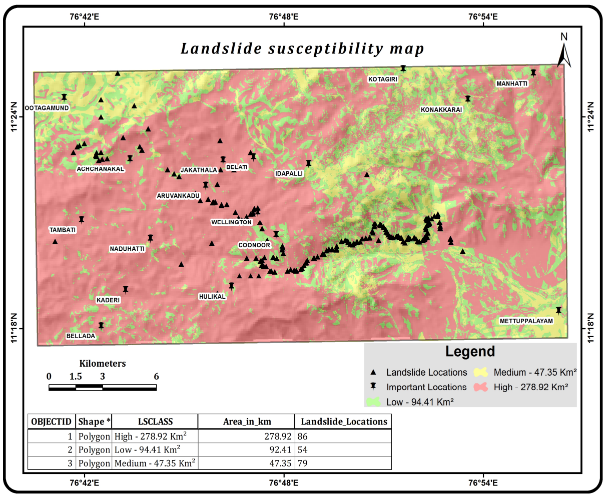

Figure 2 Landslides Vulnerable and Hazards Map

METHODOLOGY

To achieve the above-said objectives, related data were collected and terrain system thematic maps using remote sensing and GIS study relating to the study area was prepared. The related data were collected from agencies like disaster mitigation management, southern railway department, Public Works Department, Surface and Groundwater Division in Chennai, and National Remote Sensing Agency in Hyderabad. From the collateral data, rainfall and water level maps were prepared and interpreted. The drainages and surface water body maps (existing tanks) were prepared from Survey of India Toposheet at 1:50,000 scale. The geology map was collected from Geological Survey of India (GSI). The Soil map was collected from Soil Survey of India (SSI). These maps was traced, registered and digitized to prepare the spatial distribution of individual litho-units.

The Resourcesat-2 LISS-4 FMX data from May 2015 were used to prepare land use land cover and landforms studies. The results were taken into GIS platform to prepare the thematic maps & the landslides inventory. Finally to find out the landslide locations with respect to rainfall, water level, geology, soil, geomorphology, land use/land cover, lineament density, drainage density, slope.

RESULTS AND DISCUSSION

Rainfall and Water level vs. Landslide

The rainfall data interpretation during the years 2005 to 2014 revealed that, highest rainfall precipitation was noticed in 2009 at the range of 1718 mm. The entire study area received more than Tamil Nadu average annual rainfall in the range of 998 mm. The higher rainfall was noticed outer portion of the study area, Devala, Ellamanna, Naduvattam and Upper Bhavani during the study period. The high amount of rainfall was noticed in Devala rain gauge station, and the lowest rainfall was noticed in Karamadi station.

Observation wells are noticed in shallow depth of water level except a six observation wells at Nilgiri district such as Thorapalli, Gudalur and Aravenu. Other three wells at Coimbatore as Marudur, Therampalayam and Karamadai were observed to be near the surface level. Overall study area fell in shallow depth of water level except at three observations well, namely Marudur, Karamadai and Therampalayam.

Geomorphology vs. Landslide

Within the study area, the Nilgiri plateau has steep slopes to the south, and gentle slopes to the north and near ridge tops. It forms a part of the Coonoor river basin with the ridge connection. Tiger Hill and Kori Betta lie to the north and Coonoor River to the south. The area has an elevation difference of 1,641 m with lowest areas near Kallar farm (400 m) and highest on the Kori Betta ridge (2,041 m). The area west was noticed highly dissected slopes to the east of Marapallam. It is high landslide frequent locations.

Geology and Soil vs. Landslide

The study area is characterized by three types of geology namely Archaean, Proterozoic and Cenozoic age of rock formation. The spatial distribution on the geology map reveals that major portions of the study area are occupied by Archaean group of rocks. Field evidence proves that geologically, weathered charnockite and dolerite dyke rocks are relatively higher landslide prone zones.

Soil Type is a most important feature for the landslide studies. In that, seven soil series were encountered in the study area. Soil type was categorized based on the physiography, topography and drainage.

Landslide Vulnerable and Hazards

Landslides cause significant economic loss or even life every year in mountainous areas. Therefore, AHP landslide susceptibility mapping is important in such regions to assess the possible location of risk, to develop a reliable and practical mitigation program and to plan hazard management. Each thematic maps such as Geology map, Soil type map, Annual average rainfall map, Slope map, Land use/land cover map, distance from the Drainage map, Distance from the road map and Geomorphology map provides certain clues to demarcate the Landslide Susceptibility map in the study area. In order to g*et al*l these information combined, it is essential to integrate these data with suitable factor.

There fore, numerically these information is integrated through the application of GIS. Various thematic maps are reclassified on the basis of AHP weightage assigned and brought into the "Raster Calculator" function of Spatial Analysis tool for integration. A simple arithmetical calculation has been adopted to integrate various thematic maps.

The final Landslide susceptibility zonation map (Fig. 2) was prepared showing the three zones, namely 'High Susceptibility Zone', 'Medium Susceptibility Zone' and 'Low Susceptibility Zone'. Highlight of this study is that, spatially 278.92 Km^2 areas are high landslide zone and 47.35 Km^2 area was identified the moderate landslide hazard zone.

CONCLUSION

This objective is to map rainfall-induced and various other parameters with the help of landslide hazards over a region by using GIS. From this study, it is interpreted that the distribution of landslides is largely governed by a combination of geo-environmental conditions, such as geology, soil type, annual average rainfall, slope, land use/land cover, drainage density, lineament density, geomorphology and annual average water level.The highlight of this study is that, spatially 278.92 Km^2 areas are high landslide zone and 47.35 Km^2 area was identified the moderate landslide hazard zone. Most of the existing landslide locations are presented in the above mentioned area. The frequency of landslide is more in the vulnerable zone and hazard zone portions of the study area.

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