

LANDSLIDE ZONATION MAPPING – KONKAN RAILWAY, RATNAGIRI REGION, MAHARASTRA

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ABSTRACT

Landslide is a sudden downward movement of rock or soil mass movements on slopes with or without true sliding. This sudden movement of slope forming material causes extensive damage to life and property. When a landslide occurs in an active communication network like Highway, Railways, etc., the results will be catastrophic. The Konkan Railway alignment was made mostly (28% of total length) in deep Rock, Rock Soil cuttings which are underlain by traps. During rainy seasons these steep slopes without toe support, failure are occurred frequently. The common types of failures are boulder falls, slides and slump etc., which damages the railway track structure. Few occasions, it lead to fatal train accidents. Many times accidents due to landslides were averted by the active warning systems like Inclinometers, Boulder nets, Raksha Dagha unit, ACD systems but the vulnerability to slope failures still exists. So, it is necessary to implement suitable permanent site-specific control measures for the vulnerable cuttings to avoid any failures in the future. An area of 163.6 sq.km is taken for the study in which nearly 22 km of Konkan railway alignment passes through number of cuttings, bridges and tunnels. The landslide hazard zonation is prepared by using Multicriteria analysis in ARC MAP-GIS software by preparing various thematic maps like soil, geology, geomorphology, drainage density, slope and land use etc. The output map is used to monitor and to implement the slope protection measures in the railway cuttings. The final output map contains landslide hazard zonation classes like High hazard, Medium Hazard and Low hazard, which gives the possibility of landslide occurrence in relative terms.

1. INTRODUCTION

Landslides are not uncommon phenomena in Western ghat region. Every year during monsoon period the Konkan railway route faces number of unusual incidents like rock fall, soil slides, soil mixed boulder slide, spread along the track causes extensive damages to the track structure and human lives. Konkan railway carries thousands of passengers every day through its challenging terrain condition. Konkan railway has deep cuttings along its route with unfavorable slopes and extreme climatic conditions. In June 16th 2004 an accident due to boulder fall in the track lead to the derailment of Matsyagandha Express in this route, killing 16 passengers and injuring almost 100. It is clear the delineation of the vulnerable zones will be more helpful for the sustainable construction activities, implementation of protection measures thus to prevent any failures in the future. Wadekar (2003) has described the nature of Konkan railway cuttings and various types of failure during rainy season, he also added that a continuous effort are made to stabilize cuttings to prevent boulder falls and soil boulder slides along the track by providing control measures like concrete retaining structures for soil cuttings and high strength steel nets for rock cuttings.

In Rathnagiri taluk about 163.6 sq.km has taken for detailed study. Within this area the cuttings are found very steep up to 85° at some locations and the remaining slopes are with a minimum of 45°, which also shows development of cracks during rainfall seasons. The Konkan railway route of length about 22 km passes through this study area. Konkan railway has single line railway route, every day more than 20 trains' passes through this area with thousands of passengers. The frequency of train movement is high and the vibrations caused by the trains and minor tremors can trigger some local slides when the existing condition of the slope is highly prone to failure. So, it is necessary to study the region thoroughly and come out with the best result after a careful examination of all the contributing factors. Unless other wise the evaluation is properly made on stability factors, the vulnerability is going to be high in future due to increasing traffic and developments. So, this area is taken into account for the study. Landslide hazard Zonation map is prepared for this area by using various thematic maps in Geographic Information System software. Mukherjee et. al., (1998) have studied debris slides of Verandah Ghat of west coast of India and concluded that the debris slide must have been due to a continuous cause of heavy rainfall. The landslide hazard zonation map of various active slide zone has been

drawn and finally, out of the total area the various vulnerable zones have been identified by him. Anbalagan (1992) has on the landslides hazard zonation and various causes for landslides and made a general review of principles of landslides. They have also explained about the instruments and instrumentation techniques for monitoring of slope movements with the objective of unfolding the basic mechanism of landslides and other mass movements. Matual and Holzer (1978) have proposed a method for multi purpose engineering geological classification of rock masses that emphasized structure, having application to assessment of slope stability.

2. STUDY AREA

The study area is located in the part of Ratnagiri taluk in Konkan region. This covers an area about 163.6 sq.km, which is shown in the location map (Fig 1). The study area lies between 16°55'00"N and 17°05'00"N Latitudes and 73°20'00" E and 73°25'00"E Longitudes. Nearly 15 villages covered within this area. The Kajali River and number of streams, which flows towards westward in this region.

2.1 Data products used

In this study the following data products, maps and softwares have been used. The study area of 163sq.km is fully covered by 2 Survey of India toposheets (47H\5 and 47G\8) of scale 1:50,000. Toposheets of survey of India have been utilized as main primary input to prepare the base map, drainage map and contour map. Indian Remote Sensing imageries IRS-1B Feb1993 and IRS-1D Dec 1998 are used in this study to assess the landform features. Thematic maps like Geomorphology and Land Use have been extracted out from this satellite imagery using ARC MAP GIS software has been used to digitize, creating data base and analysis.

2.3 Physiography

The physiography of Konkan region is typical for its irregular landscape, rugged and hilly nature of the terrain. It is a small and narrow strip of land with sahyadri range on east and the Arabian Sea on the west. Deep valleys of east-west flowing rivers, which have deep gorges in the plateau and wide creeks as they approach the sea, carve the intermediate landmass. The bed level of the rivers is very close to sea level and the tidal range reach up to about 4 to 5 km inland from sea. In between the rivers, are high rising ridges or plateaus with elevations rising up to 280m above mean sea level.

2.4 Geology

The Konkan region is fully covered by laterite and Deccan trap, which is formed due to volcanic eruption of about 65 million years back. The study area characterized by moderate (5°) to steep (80°) slopes with a maximum relative relief of 280 meters. Laterite formation is noticed about 70.7% of the study area. The flow of water, washed away the weathered materials along the slope, which left the trap exposed along the valleys.

2.5 Land use Mapping Technique

The land use map classification is based on the activities such as agriculture, grazing, forest development and urban use. The minimum mapping unit adopted by United States Geological survey (USGS) (Witmes, 1988) is followed here for this scheme. Land use refers the present nature of landforms due to human activities and the various uses, which are carried on land. The satellite imagery is manually interpreted and converted as a thematic layer, which is used for analysis after assigning weightages to the individual classes. The Land Use details are given in **Table 1**. **Figure 2** shows the Land Use details.

2.5 Methodology

Assigning the weightages or giving rating to the various relevant parameters forms the most crucial part of preparing the Landslide Hazard Zonation maps. The prior knowledge on the terrain parameter and rainfall in the area of the reported landslides was used in the ranking. The valuable terrain and rainfall parameters has used in landslide susceptibility mapping. The weightings were assigned to each terrain parameter to reflect its importance in the occurrence of landslide and the scores are assigned to the individual classes within each parameter, which denotes the degree of hazard probability due to a particular parameter. The probability of landslide from a portion of the hilly terrain depends on the cumulative effect of the individual features. The weight and score details are given in **Table 2**.

Landslide Hazard Zonation map is prepared by using the integration of various thematic layers such as Geology, Drainage density, Geomorphology, Land Use and Soil etc. These thematic layers are analyzed through multicriteria and overlay analysis. The entire area is delineated according to their landslide probability in relative terms of three classes like Low hazard, Medium hazard and High hazard.

3. RESULTS AND DISCUSSION

Landslide hazard zonation study plays an important role in planning for the future developmental activities in the Konkan railway area. In this analysis hazard map is prepared to identify the areas susceptible to instability. The terrain is classified according to the degrees of actual or potential susceptibility to landslide hazard. So, that these areas can be given priority to taken care to avoid or to mitigate the risk of landslides. The output map shows nearly 45.09% of the study area is under high hazard zone and 43.61 %of the area under low hazard zone. The study area is having plateau region with steep slopes, these slopes are used for cultivation purpose. Most of the area is covered closer to these slopes, which are steeper in nature coming under high hazard zone. The landslide hazard zonation map is shown in **Figure 3 and Table 3**, which present the details different hazard classes.

3.1 Reference

Anbalagan. R., (1992 b), Terrain evaluation and landslide hazard zonation for environmental regeneration and land use planning in mountain terrain. Proceedings of International Symposium on Landslides, 10th - 14th February, Christchurch, pp.861-868

Nagarjan. R., R., Khire. M.V., (1998), Debris slide of Varandhghat, West coast of India, Bulletin Engineering Geology and Environment, Vol: 57, pp.59-63.

Wadekar .V.S,(2003) Rock cuttings in konkan railway“Geo technical issues of Konkan region” Konkan Railway corporation Mumbai

Mukerjee A., (1998), Temporal remote sensing data and GIS application in Landslide Hazard Zonation of part of Western Ghat, India and Pub: International Journal of Remote Sensing. Vol:19, No.4, pp.573-585



Figure 1

S.No.	Description	Area In Sq.km	Area in %
1.	Water body	13.03	7.96
2.	Settlement area	48.54	29.66
3.	Crop land	30.45	18.65
4.	Forest land	54.45	33.28
5.	Fallow land	2.2	1.34
6.	Barren land	14.77	9.02
7.	Swampy region	0.11	0.06
8.	Sandy region	0.05	0.03
		163.6	

Table 1 Land Use Categories

S.No.	Description of feature	Score	Weight
1.	Soil map	10	
	River bed sand		3
	Laterite		7
2.	Geomorphology	25	
	Valley fill		1
	Valley		10
	Shallow pediment		3
	Denudation hill		6
	Table land		4
3.	Geology	5	
	Laterite		4
	Trap		6
4.	Landuse map	15	
	Water body		1
	Settlement		9
	Crop area		7
	Forest area		3
	Fallow land		2
	Barren land		4
	Swampy land		1
	Sandy area		1
5.	Drainage density map	25	
	Low		10
	Medium		8
	High		6
	Very high		2
6.	Slope map	20	
	Gentle $<14^{\circ}$		2
	Medium $15^{\circ}<24^{\circ}$		6
	Steep $25^{\circ}<$		10

Table 2 shows Weight and Score details

S.No.	Description	Area in sq.km	Area in %
1.	Low hazard	71.34	43.61
2.	Medium hazard	18.49	11.3
3.	High hazard	73.77	45.09
	Total	163.6	

Table 3 Landslide Hazards details

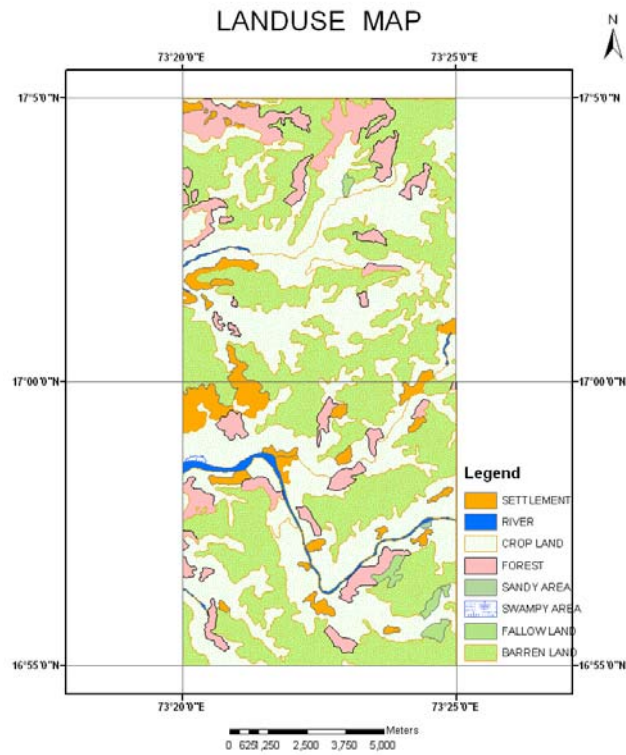


Figure 2

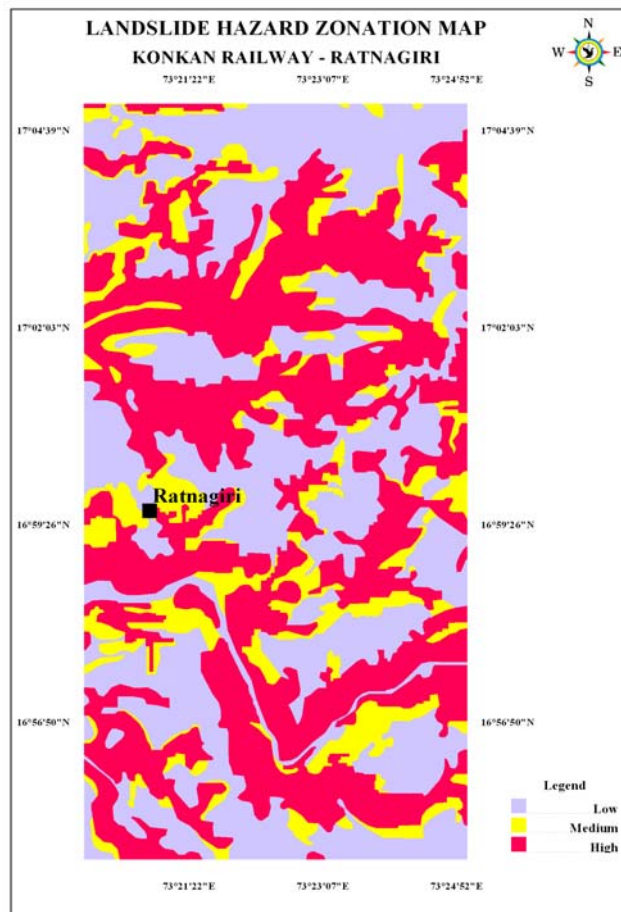


Figure 3