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Landslide Vulnerability Zonation of Ghod River Basin by Using GIS and Remote Sensing

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Abstract:

A study of landslide vulnerability zonation was carried out by using GIS and Remote Sensing techniques for the Ghod river basin of Maharashtra. As we knew that on 30 july 2014 a drastic landslide was occurred at Malin village of Ghod river basin which threatened 151 lives and heavy structural damage of village. In present study we have analyzed various thematic layers such as drainage density, slope, soil texture, rainfall, land use/ land cover and geology. Multi-criteria analysis was carried out by assigning particular weightage to layer.

Key Words: Landslide, Mapping & Assessment, GIS & RS, Disaster Management

Introduction

Globally, landslides cause approximately 1,000 deaths per year with property damage of about US$ 4 billion (Pradhan B, et al 2009). Landslide is the major disaster event occurring in the hill y region. It is an event occurs slowly and rapidly. It classified differently as per its types. Landslide creates damage to mankind and infrastructure. These events are associated with pre and post of earthquake, soil erosion, rainfall and anthropogenic activities. The combination of remote sensing and GIS can able to prepare landslide vulnerability zonation mapping. The application of remote sensing methods, such as aerial photographs and satellite images, are used to obtain significant and cost-effective information on landslides. Landslide hazard maps are of great help to planners and engineers for choosing suitable locations to implement developments (Pradhan B, et al 2008). There are other new approach to landslide hazard evaluation using GIS; data mining using fuzzy logic and artificial neural network methods have been applied in various case studies (Pradhan et al. 2009; Pradhan and Lee 2009)

The data from remote sensing and geographical information system techniques is used for the generation of various thematic layers, such as drainage density map, land use and land cover, geology, soil texture, slope map of the region, and rainfall data. The weightage and rank is given to each and every layer and a feature of the layer and weighted union overlay technique is used to delineate the landslide vulnerability zones. Therefore, the present study focuses on the mapping and identification of landslide vulnerability zones in the Ghod river basin.

Objective

The main objective of the research work is to identify and assess the Landslide prone area of the Ghod river basin using GIS technique.

Study Area

Ghod river basin is bounded by geo-coordinates $18^0$30'20''N To $19^0$24'34''N and $73^0$32'10''E to 74^0 43' 51''E and is located in Pune and Ahmadnagar districts of Maharashtra. It flows in an east-southeast direction for 200 kilometers before it confluence with Bhima.

Gis And Remote Sensing For Landslide Zonation

A GIS is a computer based system for the integration of spatial data from various sources and for the analysis, manipulation and display of results from data. It is an outstanding tool for the management of large quantity of spatial data with minimum computational error. The remote sensing and GIS techniques have wide range of tools and techniques for effective mapping of risk from landslide and damage assessment from the landslide disaster. The remote sensing data of temporal variation will provide unique and accurate results for optimal measurement of damage of resources in post disaster activities. Space borne remote sensing technology is providing spatial, multi-spectral and repetitive information for planning. The Remote Sensing and GIS is gives cost effective and accurate results for application in various fields. The GIS techniques and remote sensing data can be used in various disaster management applications such as flood mapping, drought monitoring and mitigation, forest fire analysis, landslide Zonation, risk of disaster, potential sites of landslide, soil erosion risk assessment, problem identification, and site suitability analysis for various activities.

Methodology:

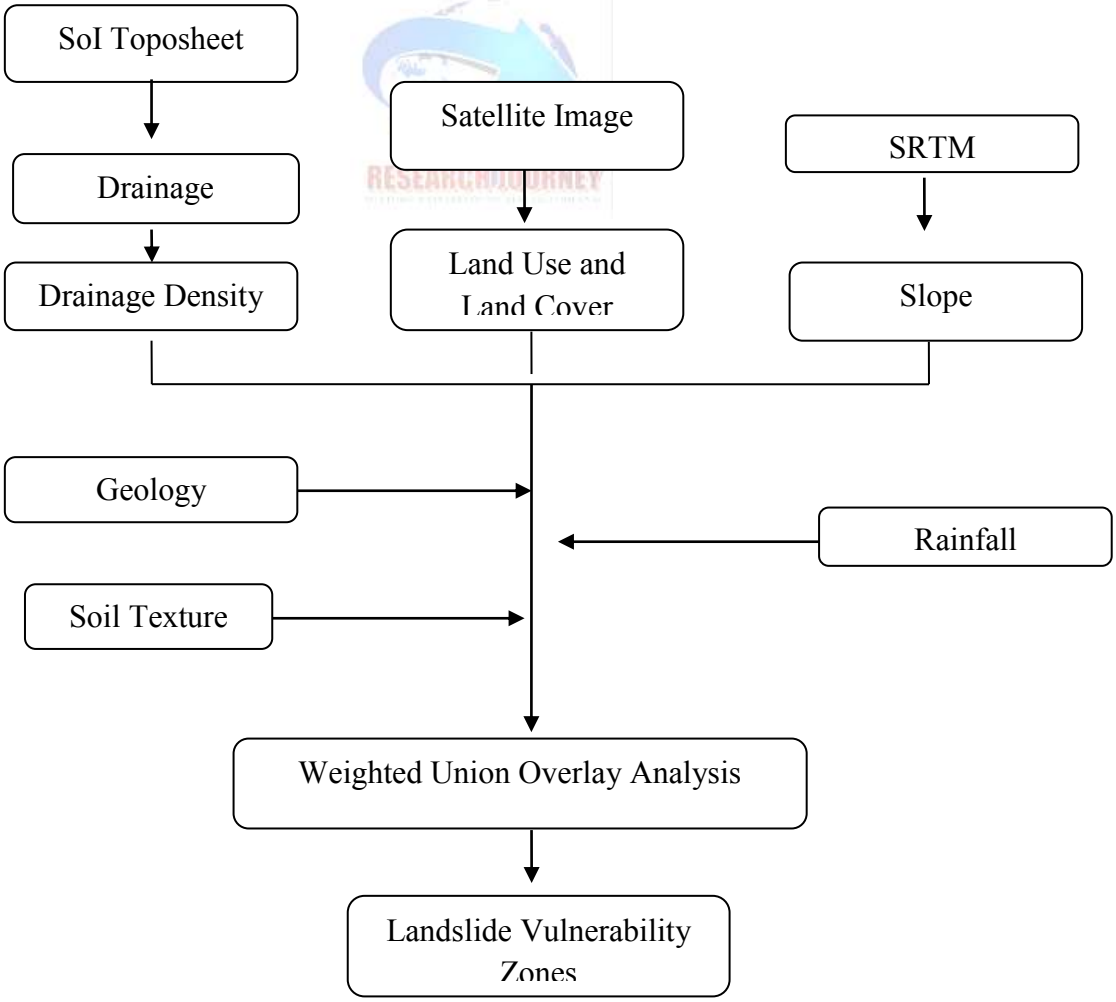

Fig.1 Flow Chart of Methodology of Landslide Vulnerability Zones

Landslide vulnerability zones are prepared using different thematic layers. The drainage of the area is digitized from the survey if India toposheet using ArcGIS software. The line density tool is used for the calculation of the density of the stream network. The land use and land cover map is generation using the satellite data of Landsat 8 and supervised classification method from the ERDAS software used for classification. Slope map is derived from the SRTM data which is obtained from the GLCF website. Rainfall of the area is taken from the Indian Meteorology Dept, and interpolated for the river basin. Soil texture layer is prepared using the NBSS and LUP soil texture map. The geology of the area is taken from geological survey of India. After the creation of all thematic layer according to knowledge and impact of that thematic layer and features of that particular layer weightage is assigned to all thematic layer. The weighted overlay technique from the spatial analyst tool in ArcGIS 9.3 software used for the analysis and delineation of landslide vulnerability zones the area.

Thematic Layers

1 Drainage Density

The stream network of the selected part is digitized from Survey of India Toposheets. The drainage network was digitized from the SoI toopoheet and drainage density is calculated in the ArcGIS 9.3 software using Line Density tool. The higher ranks were given for higher density. Middle part of the basin is having higher density of drainage and the higher density of the drainage indicate the high flow of water and in resulting to higher rate of landslide.

2 Slope

The slope map in generated from the SRTM, data of the study area, in this area, there are 5 categories of slope were found in degree, they are0-0.41, 0.41 -1.09, 1.09 - 2.09, 2.09 - 4.97 and 4.97 - 10.80 degree Higher degree of slope results in rapid landslide.

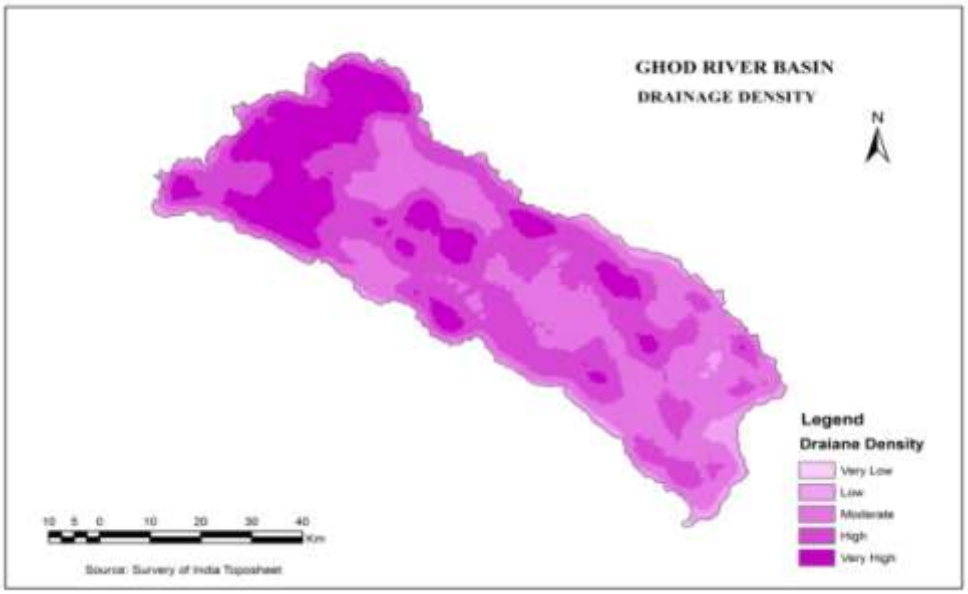

Fig.2 Drainage Density

3 Soil Texture

The soil texture is a significant aspect in the landslide Zonation. It affect on the movement and infiltration of water into soil and it control the loosening the soil particle and lead to slide the layer of soil. The clayey calcareous soil group covers the major part of the basin. The soil texture groups found in the basin were clayey calcareous, fine calcareous, loamy soil with severe erosion, clayey soil with moderate erosion and clayey soil with severe erosion. The infiltration rate of the surface runoff depends upon the porosity and permeability of the soil. (Fig.3)

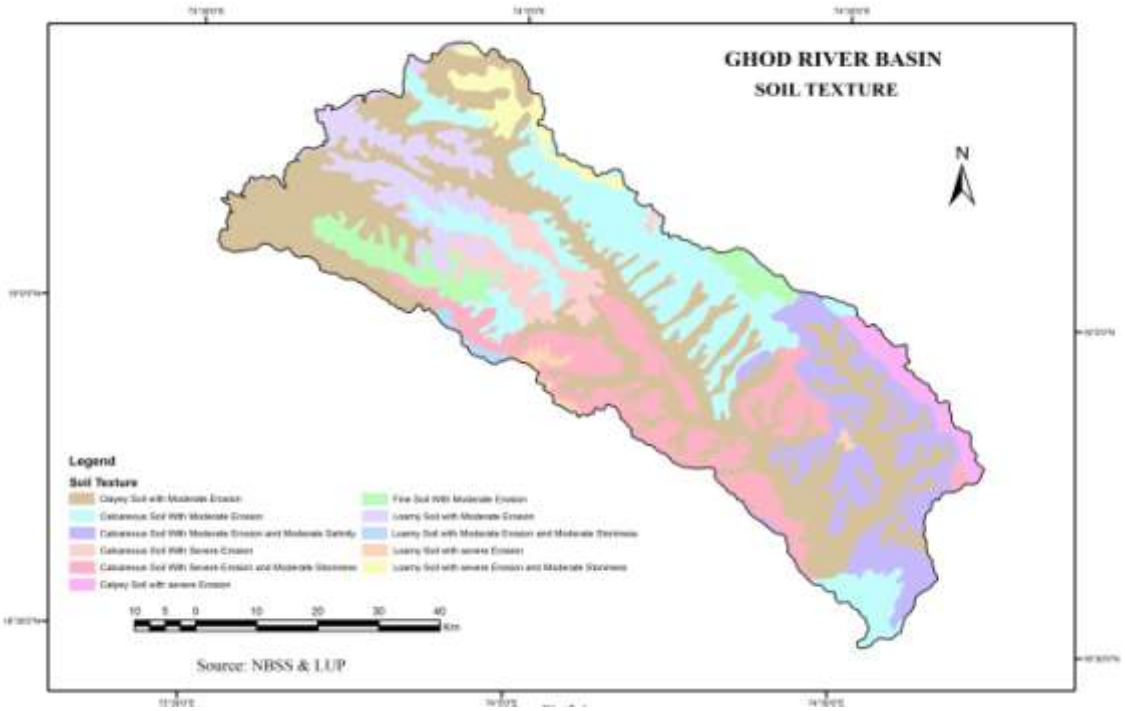

Fig.3 Soil Texture

4 Rainfall

The study region receives rainfall from the south-west monsoon. The slope and intensity of rainfall directly affects the infiltration of water and surface runoff and resulting into the land movement and landslide in steep slope area. The rainfall is the one of reason for the landslide. The higher intensity of rainfall is resulting into the higher probability of landslide. The region is categorized into the three classes for the assessment of landslide.

5 Land Use / Land Cover

The land use and land cover includes manmade and natural features on the earth's surface. The land cover with agriculture and vegetation affects on the surface runoff and results into low rate of soil erosion and low rate of slide of the land in slope region. Land use and land cover plays an important role in mapping of damage in land slide. The land use and land cover for the present study was derived from the Landsat ETM satellite image which was downloaded from the GLCF website. The map was prepared using ERDAS Imagine software and using supervised classification method. The Ghod river basin covered is by different classes such as forest, barren land, built-up area, water body, agricultural land, and others. Most of the area was under the agricultural land in the study area.

6 Geology

Geology is the determining factor of movement of rock and landslide. The river basin is formed by basalt rock in Deccan trap. It consists of Diveghat formation. Purandhargarh formation includes eight basaltic flows and Mahabaleshwar formation occurs at the top of isolated hills and hill ranges trending north-west to south-east comprising of nine aa flows. The flows are phyric in nature and are mainly exposed and western part of basin (Fig.5).

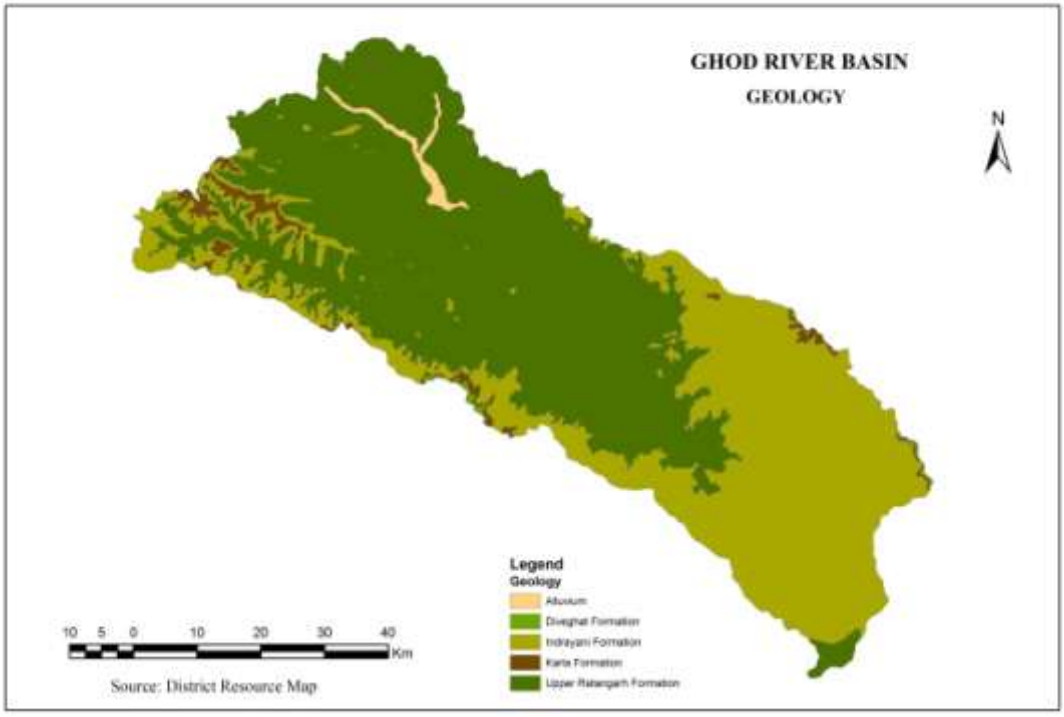

Fig.4 Geology

Assigning Weightage To Layer

The influence of the factor used for delineating the groundwater potential zones such as land use and land cover, geology, soil texture, slope, rainfall and drainage density were examined and assigned appropriate weights to the each feature (Table 1). The Weightage was assigned to each feature on knowledge based method and influencing factor of the feature. The value one is assigned to the less potential and five and in some layer three is high potential. The value one is assigned to the less vulnerable and five and in some layer three is high vulnerable.

Table 1 Weightage of Layer

Sr.No.	Thematic Layer	Feature	Weightage
1	Soil Texture	Clayey Calcareous Soil	1
		Clayey Soil With Moderate Erosion	2
		Clayey Soil With Severe Erosion	4
		Fine Soil Moderate Erosion	3
		Loamy Soil With Severe Erosion	5
2	Geology	Diveghat Formation	3
		Mahabaleshwar Formation	2
		Purandhargarh Formation	1

3	Slope	0- 0. 41	1
		0. 41 - 1.09	2
		1.09 - 2.09	3
		2.09 - 4.97	4
		4.97 - 10.80	5
4	Drainage Density	Very Low	5
		Low	4
		Moderate	3
		High	2
		Very High	1
5	Rainfall	400- 460 mm	1
		460 - 510 mm	2
		510 - 590 mm	3
6	Land Use and Land Cover	Agricultural Land	4
		Built-up	2
		Fallow and Barren land	5
		Forest	3
		Water body	1

Results And Discussion

The landslide vulnerability zones demarcated for the Ghod river basin using integration of different thematic layers such as geology, soil texture, rainfall, land use / land cover, slope, and drainage density etc (Fig.5). The weight and rank is assigned to each feature of the layer and weighted union overlay analysis tool from the Spatial Analyst toolset of ArcGIS Software, used to perform overlay analysis. The result of overlay analysis has been classified into five classes such as very low, low, moderate, high and very high vulnerable to landslide. The hilly area of basin having high to very high vulnerable to landslide and plain region of the basin having low to very low in reaming part of the basin .

Conclusion

The different thematic layers and assigned Weightage and rank in a weighted overlay analysis are an effective tool for the accuracy of the results in landslide vulnerability zones. The thematic layers such as land use / land cover, soil texture, rainfall, geology, and drainage density of the region were used for the delineation of the landslide vulnerability zones mapping. The remote sensing and GIS technique is very accurate and effective tool to mapping. These are found efficient to minimize the time, labor and cost of landslide vulnerability zones mapping. The Ghod basin is classified into five classes as very low, low, moderate, high and very high vulnerable to landslide.

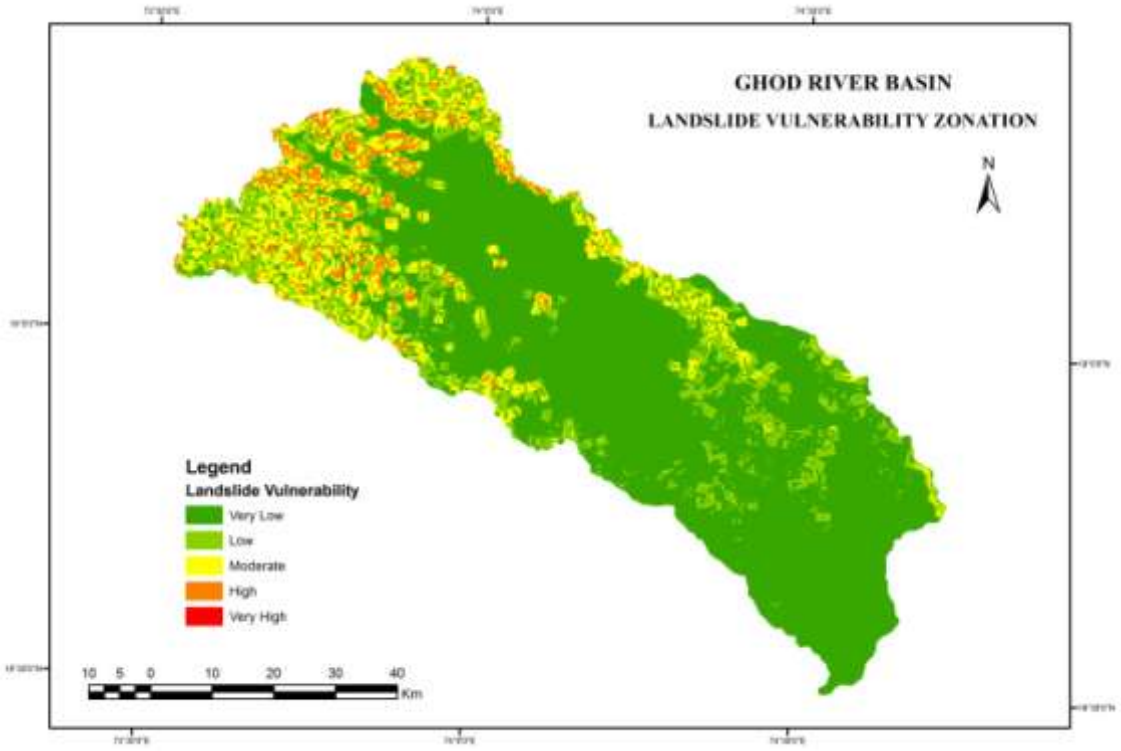

Fig.5 Landslide Vulnerability Zonation

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