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A Review on Identification of Landslide Potential Areas Using GIS and Remote Sensing

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Abstract: *For the three years (2018, 2019 and 2020) many parts of our country had experienced sever landslide events. Kerala was one among the most affected state in the country. The majority of the landslide events were during the monsoon season which was from June to September. As the state was not prepared for this sudden change of climate, many areas were severely affected, leading to loss of life and property. This paper identifies various reasons for occurrence of landslides and the methods that are used for landslide zonation using GIS and remote sensing. The common factors causing landslides are studied which includes the curvature, slope degree, slope aspect, drainage density, rainfall intensity etc. The various methods of analysis such as weighted overlay method, analytical hierarchy process and frequency ratio methods are also discussed for the landslide zonation mapping. The preparation of Digital Elevation model using the GIS is also considered in the study.*

Keywords: *Remote sensing, GIS, Landslide Zonation Mapping*

1. INTRODUCTION

A landslide may be defined as the mass movement of earth, rocks, debris down a sloped section of land. The major causes of landslides are rain, earthquakes, volcanoes etc that make the slope unstable. Highly populated areas are more affected by landslides that may cause a huge loss to life and property. The occurrence of landslides is caused due to a number of various factors in particular region. Soil piping was also found to be one of the reason for the slope instability. The analysis of various factors are done for the identification of landslides. Landslide zonation gives the information about various causes of landslides such as slope failures. Landslide zonation is used for the prevention and mitigation plans to avoid the loss of life and environment. There are a variety of factors that affect the stability of slopes causing landslide, out of which the major factors are slope aspect, slope degree, drainage density, rainfall, curvature, elevation, land use / land cover and lineaments.

There are various methods used for the analysis of landslide susceptibility out of which the integrated method using Geographic Information System (GIS) and Remote Sensing is more commonly used. The images of remote sensing are combined with the GIS of the study area.

Remote sensing can be defined as a process of collection of information about an object, an area or a phenomenon without coming into contact with it. Human eyes can be taken as an example of a remote sensing device wherein the information can be gathered about our surroundings. This is done based on the amount and nature of reflection of visible light from an external source such as sun.

A Geographical Information System (GIS) may be defined as a hardware or a software, a data, organization and professionals to analyze and represent a geographic data. GIS is used to store the data which provides the descriptive information about the map features. Therefore, GIS combines with geographic and various types of data to create the maps and reports thereby enabling the users to collect, manage and interpret the information based on the location in a planned and systematic way.

Remote sensing is merged with GIS. The remote sensing gives the input data. The data obtained from remote sensing is collected and converted for spatial data analysis or modeling applications done through GIS software. This is a cost effective method. The spatial data is stored in GIS which can be analyzed using GIS methods and tools.

GIS and Remote sensing tools plays one of the most important role in improved landslide inventory mapping and landslide susceptibility. The application of GIS is utilized for the prediction and mapping of various landslide events in susceptible areas of our Country.

A natural disaster has a huge impact on the sustainability of the area. this leads to the loss of life and property. A proper evaluation and analysis need to be done to overcome the impact due to the disaster. (Dyah Wahyu Sukhmaningsh et.al 2020). The analysis of landslide is done by combining Remote sensing and GIS (G. Anjenayulu et.al 2019). The digital elevation model is prepared using the obtained data. The various factors causing the landslides are studied which includes the slope degree, slope aspect, drainage density, land use/land cover, geology, geomorphology, rainfall intensity etc (Padmakumari et.al 2019). The satellite images of the landslide area before and after the occurrence of the events were taken using various remote sensing satellites (R. N agarajan et.al 1998). For this purpose, a high resolution satellite imagery is used to get a clear picture (Ibrahim Shaik et.al 2019). The analysis is done using various method such as weighted overlay method (WOM) where the weightage is assigned to the causative factors baed on their impact (Akhilesh Kumar et.al 2019). Another method of analysis is the Analytical hierarchy process which is similar to the WOM method where the weightage is assigned to causative factors based on their influence on landslide occurrence (Amitanshu Pattanaik et.al 2019). The analysis was also done using frequency ratio method which is a probabilistic method done by taking ratio of total landslides in a particular area or probability of occurrence of landslide to the non-occurrence area (Tri Dev Acharya et.al 2018). The analysis done using various methods helps to properly identify the landslide prone areas so that preventive measures can be taken to overcome the loss of life and property (Haiqiang Guo et.al 2015).

2. OBJECTIVES

The main objective of the present study is to:

Review various literatures and study the various steps involved in landslide hazard zonation mapping.

Study the causative factors that lead to the disaster to occur.

Discuss the various methods that are used for the analysis for the preparation of Digital Elevation Model (DEM).

3. METHODOLOGY

3.1. Data Used and Methodology

The topographic sheets of the study area is obtained from the Survey Of India toposheets. The geological setting of the study area is obtained from the Geological Survey of India. India Meteorological Department gave the rainfall data of the area. The remote sensing image of the study area is obtained from the satellite imagery. The maps were digitized in the GIS software and the Digital Elevation Model of the study area as built.

3.2. Data Preparation

The data preparation was done by using Remote sensing application where the satellite images of the study area was obtained with regard to land use or land cover, drainage density, slope degree and slope angle.

3.3. Digital Elevation Model

From the obtained data, the 3D representation of study area also known as Digital Elevation Model (DEM) is prepared. The slope map, aspect map, curvature and the elevation which can be defined as the terrain height from the Mean Sea Level (MSL) is prepared from the Digital Elevation Model (DEM) of the area which is found to e very important for the determination of landslide susceptibility area.

3.4. Bhuvan Dataset

The lineaments or the linear topographic feature that reveals the characteristic of the subsurface structure of the earth's crust is collected from Bhuvan dataset developed by the ISRO which is a web based utility that allows the users to explore a set of maps based contents.

3.5. Survey of India Toposheets

The geographical details of the study area is obtained from Survey of India toposheets of scale 1:50000.

3.5.1. Rainfall Dataset

The rainfall data of the area is obtained from Indian Meteorological Department which is one of the triggering factors for the occurrence of landslide. The area with heavy rainfall is more susceptible to landslides.

3.5.2. Analysis

The analysis is done based on many methods such as Weighted Overlay Method, by integrating relative frequency and predictor rate, using Analytical Hierarchy Process and Comprehensive Index Method.

3.5.3. Weighted Overlay Method

The weighted overlay method can be defined as a direct and adequate method of analysis of landslides. In this method the area is divided into various zones depending upon the environmental factors. A numerical value is allotted to the cell which mathematically combines for producing a new value in the final output layer. The various factors were ranked and the factor with the lower ranking value has the lesser weightage while the higher ranked value has higher weightage which means that there is greater chance of occurrence of landslides. The resultant map of this analysis is known as the Weighted Raster Map.

3.5.4. Frequency Ratio

It is a probabilistic method of landslide analysis which is done by obtaining the ratio of total landslides in a particular area or probability of occurrence of landslide to the non occurrence of landslides. The relative frequency is used to establish the relation between the conditioning factors and the landslide events.

3.5.5. Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is similar to that of weighted overlay method (WOM) where the weightage is assigned to the causative factors based on their influence on landslide occurrence.

4. EXPECTED OUTCOMES

4.1. Slope Aspect

Slope aspect plays an important role in slope stability. The aspect map shows the direction of hill sloping to various angles. The different slopes are as follows: east facing, north, northwest, northeast, south, southeast, flat, southwest and west. The various slope aspect is generated in GIS.

4.2. Slope Degree

It is another important factor usedto check the stability of the slope. The increase in slope increases the shear stress in soil. The steeper slopes will be more vulnerable to landslides compared to other slopes. The slope map of the area is generated from the Digital Elevation Model (DEM). The lower value of slope indicates that the terrain is flat while the higher value indicates steeper slopes. The slopes are divide into five classes based on the angles i.e. between 0^o to 15^o (flat slopes) between 15^o to 25^o (moderate slope), 25^o to 35^o (fairly moderate slopes), 35^o to 45^o (steep slopes) and between 45^o to 90^o (very steep slopes).

4.3. Drainage Density

Drainage is the chief parameter for the landslide to occur. Usually the landslides are more likely to occur in areas near river basins where proper drainage is not provided. During rainy season, lack of drainage facilities is the major cause of landslide carrying huge mass of rocks and debris flowing down the slope with heavy water flow. Drainage map is obtained from the GIS software. The drainage density is classified into five types ranging from very low drainage density to very high drainage density.

4.4. Curvature

Curvature is the rate of change of gradient. The morphology of an area is determined by its curvature. The slopes may be concave, convex or flat. The slope with concave curvature is unstable and more susceptible to landslide while convex slopes are stable.

4.5. Land Use / Land Cover

The presence of vegetation is an important factor that affects the slope stability. Land use is the various operations carried out on land by humans for their benefits while the land cover is the vegetation either natural or planted which occurs on the Earth's surface. Weights of soil, pore water pressure, internal friction angle, and cohesion are the major factors that affect the vegetation which further affects the landslide. The various lands are built-up land, forests, water body, waste land, agricultural land, evergreen forest and deciduous forest. The barren slopes are more affected by landslide occurrence than the dense lands such as vegetative lands. The area with more urbanization and human activities are more susceptible to landslides.

4.6. Rainfall

Rainfall is one of the major cause for the occurrence of landslides. The rainy season usually occurs from June to September and the most hazardous landslides occurred in the month of august. Most of the landslides that took place in the area are due to the heavy rains during the monsoon season. Rainfall is one of the triggering factor that leads to the slope failure causing landslide. The rainfall data is obtained from the Meteorological Department of India. The rainfall density map is prepared by using the GIS software.

4.7. Elevation

Elevation is defined as the height of the terrain from the Mean Sea Level. This data of the area is obtained from Digital Elevation Model (DEM) using GIS.

4.8. Lineaments

The lineament is the linear topographic feature of the area that reveals about the characteristics of the subsurface structures. Lineaments are obtained from Bhuvan dataset. The lineaments is divided into six classes ranging from very low (<0.05) to very high(0.5 – 0.7).

4.9. Road Maps

It is necessary to obtain the data of the road as it helps to identify the roads that are under the risk i.e. roads located in highly unstable area. Certain measurements can be taken to protect the risky roads.

4.10. Geomorphology

The study of physical features of the area is known as geomorphology. The study of geomorphology is necessary to determine the geomorphologic features that affect the slope stability which may be a reason for the occurrence of landslides.

5. CONCLUSION

The landslide zones may be divided into very low hazard zone, low hazard zone, medium hazard zone, high hazard zone and very high hazard zone. From the review of the literatures it was found that most of the landslide took place in the southern slope due to lack of vegetation. The slopes where proper vegetation and cultivation is done was found to be more stable and less susceptible to landslides. The slopes were divided into various classes based on the slope angle. The angle between 45^{o} to 90^{o} was the steepest which was unstable and was more prone to landslides. The curvature is also an important parameter that has to be considered for the study of landslides. It was found that the slopes with concave curvature was unstable due to the accumulation of runoff water at the bottom of the slope leading to failure. One of the triggering reason for the occurrence of landslide is due to the heavy rainfall over the area with lack of drainage system. Without proper drainage system the heavy rainfall leads to mass movement down the slope. The barren surface showed more chances of landslide compared to densely vegetated areas. The GIS and Remote sensing can not only be used for mapping the risk factors but it can also be used for identification of damaged zones, for updating maps and also to give the warnings.

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