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Research Paper

Identification of Landslide Susceptible Zones Using Geographical Information System

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Abstract
The Landslides are among the great destructive factors which cause lots of fatalities and financial losses over the world every year. The aim of the research was identification of landslide susceptibility by remote sensing, data processing, GIS spatial analysis. The area studied in research is Radhanagari in Kolhapur.
Then, applying other information sources such as the existing thematic maps, we studied and defined the factors such as lithology, slope, slope aspects, annual rainfall, land use, distance to waterway, shear strength of soil .That affect the occurrences of the landslides. To get more precision, speed and facility in our analysis all descriptive and spatial information was entered into GIS analysis.

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I. INTRODUCTION

Landslide is one of the most worldwide nature phenomena that causing huge damage to property and infrastructure, losses of human lives and animals almost every year. To reduce the issues of landslide susceptibility zonation (LSZ) map of that particular area. The accurate landslide zones which have been evaluated by using frequency ratio model method that indicates more than 85% of landslide prediction accuracy. The frequency ratio scores were calculated from the casual factors and training occurrences repeatedly. The few landslide susceptibility maps were studied from the integration of casual factors that assigned frequency ratio scores. The landslide susceptibility maps were authenticated by using each validation dataset. The frequency ratio limit for a achieved susceptibility occurrence from 89.48% to 93.21%. Therefore, the landslide susceptibility accuracy is for frequency ratio model is higher than 89%. The problem of the landslide is due to topographic, excavation for construction, heavy rainfall etc. in Maharashtra Kolhapur is considered as a most vulnerable region for landslides activity.

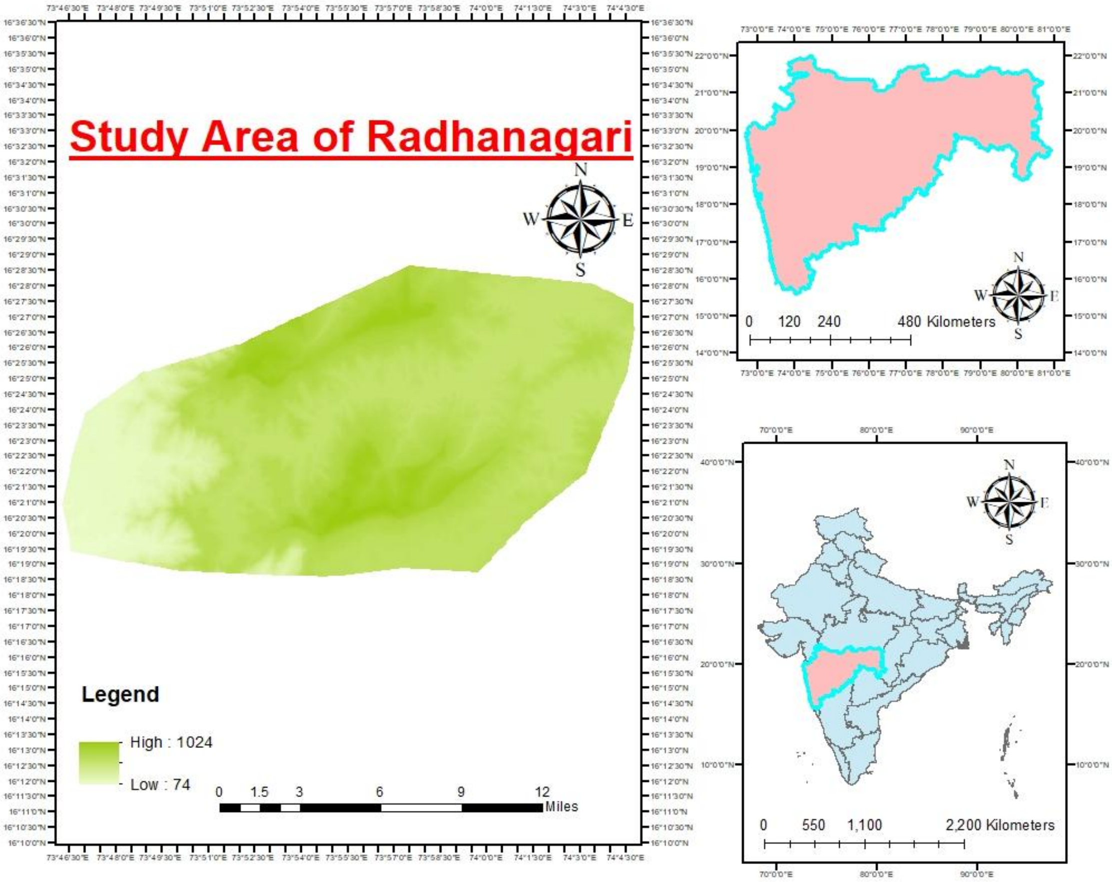
Integral to the natural process of the earth’s surface geology, landslides serve to redistribute soil and sediments in a process that can be in abrupt collapses or in slow mud flows, debris flows, earth failures, slope failures, etc.

The landslides susceptibility map study gives an idea about the stability of slope, so it can be used for future construction work and remedial measures. The remedial measures are provided to avoid landslide at certain locations. Rock fall Hazard Rating System for India (RHRSI) identifies the slopes on hilly areas, to find rock fall prone area, so that proper remedial measures can be proposed to mitigate loss. Rock fall Hazard Rating System for India (RHRSI) is a modified system for Indian Subcontinent and used to define strength of slopes in mountains and hilly areas. The landslide susceptibility maps were authenticated by using each validation dataset. Therefore, the landslide susceptibility accuracy is for frequency ratio model is higher than 89%. The most common software for landslides studies is ArcGIS package which is used for mapping landslides influenced area; maps factor preparation, overlay analysis and interpretation. GIS is an ideal tool for landslide modeling owing to its versatility in handling a large set of data, providing an efficient environment for analysis and display of results with its powerful set of tools, for collecting, storing retrieving, transforming and displaying spatial data from the real world, with the help of remote sensing devices. We also can provide many useful and use information to combine in a GIS environment with other spatial factors influencing the occurrence of landslides.

We are going to study the area is Radhanagari in Kolhapur, Maharashtra, India. Gulmewadi to Karanjphene there is a huge amount of landslide happened in 13th Sep, 2021 and also in Kanoli to Kuplewadi in 23rd Jul, 2021.

DESCRIPTION OF THE STUDY AREA

We are going to discuss the study area is Radhanagari which is in Kolhapur, Maharashtra, India. The latitude, longitude of Radhanagari is 16.36336 N 16°21´48.7919´´ and 73.82293 E 73°49´22.55246´´. The study area distance is cover 25-30m. The area covered by brown soils (Halki Kali Mati) are found in the talukas of Hatkanangle, Karvir and Radhanagari and parts of the Bhudhargad and Ajra talukas in the transition tract.



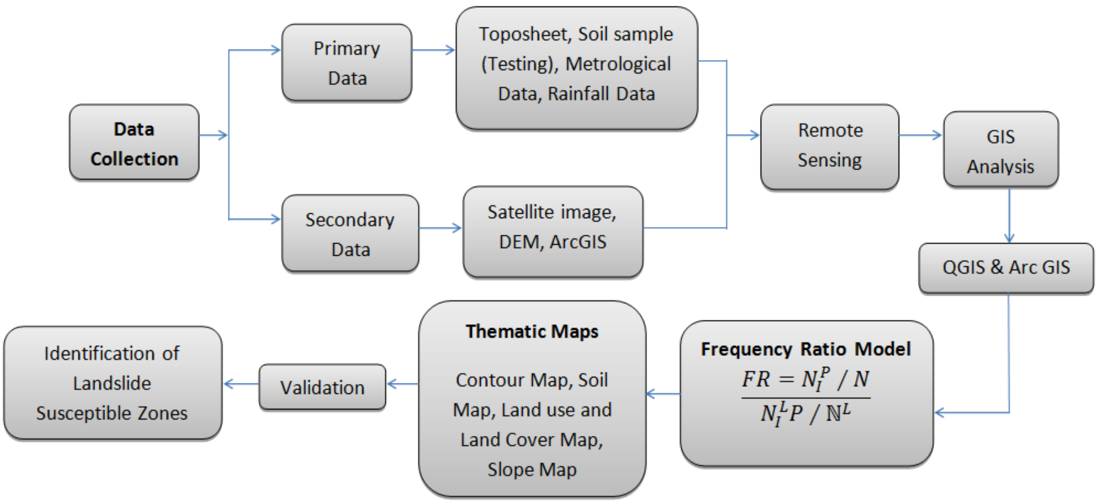


Fig: Flow of Study Work

II. METHODOLOGY

The Geographical Information System (GIS) which is based on computer-based tool for mapping of landslide prone zones and for identify geographical phenomenon exist. Landslide locations are identified by ratio is a technique to interpreting the satellite images of the topography, soil, forest and are extracted from the spatial database. These factors are taken used with an artificial neural network (ANN) to analyze landslide susceptibility. Development of landslide susceptibility in the present study are has been carried out in five main steps: 1) Data collection, 2) preparation of landslide maps, 3) Determination of the landslide conditioning factors, 4) Application of frequency ratio model, 5) Development of landslide susceptibility mapping, 6) Validation of frequency ratio model.

1) Preparation of landslide inventory map:

A landslide inventory map records the location and where known the date of occurrence and the types of mass movements that have lift discernable traces in an area.

2) Landslide Conditioning Factors:

The first dataset was derived from high resolution airborne laser scanning data (LiDAR), which contains eight landslide conditioning factors. Altitude, slope, aspect, curvature, stream power index (SPI), topographic wetness index (TWI), topographic toughness index (TRI), and sediment transport index (STI).

3) Landslide susceptibility mapping:

A landslide susceptibility map identifies areas which are subject to landslide and is measured from low to high. The landslide susceptibility map takes into account where the landslide o and what causes them (slope, soil type and the impact of the flow of water in an area).

4) Applications of Frequency ratio model:

Frequency ration model has been successfully applied as statistical approach for landslide susceptibility assessment in many regions all over the world. Results indicated the frequency ratio model is an effective method for the landslide susceptibility assessment of hilly areas. The mathematics representation of frequency ratio model is as follows;

$$\frac{FR = N_I^P \ / \ N}{N_I^L P \ / \ \mathbb{N}^L}$$

Where,

N_I^P=is the number of pixels study area in each landslides conditioning factors class.

N= is the number of landslides pixels in total the study area.

$N_I^L P$ = is the number of landslide pixels in each landslide conditioning factors class.

$\mathbb{N}^L$= is the number of all landslide pixels in total the study area.

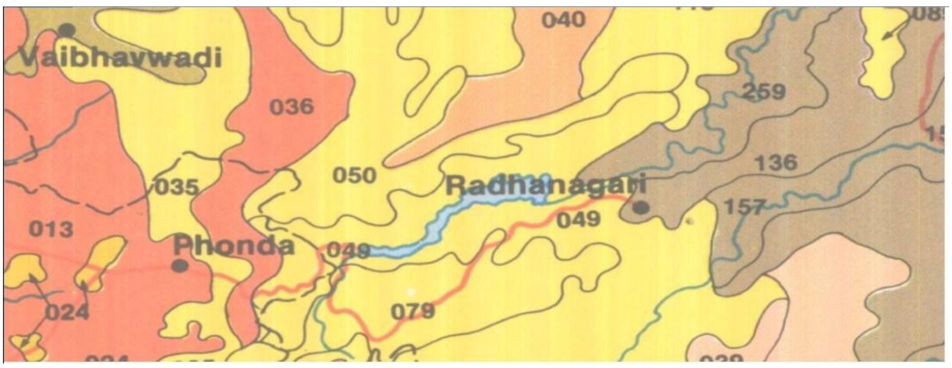
5) Data Collection:

Data for landslide susceptible zones from forest government office in India e.g., rainfall data, satellite image, Google earth images, soil samples for testing.

6) Validation of frequency ratio model:

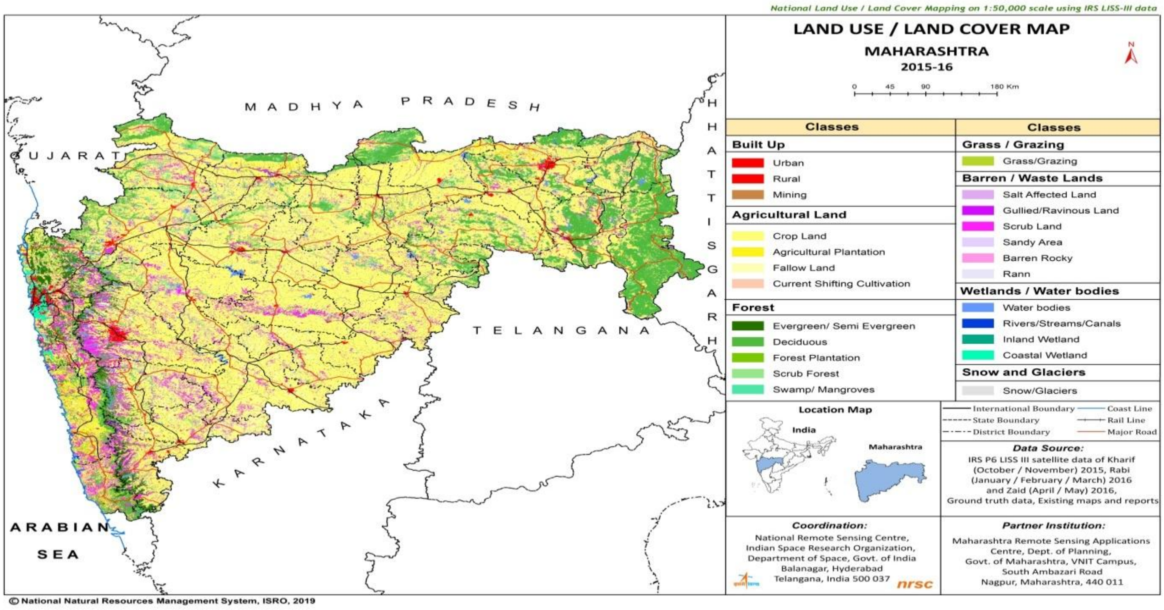
The performance of the FR model was evaluated using the Landslide Density Index (LDI). For validation, landslide area which has not been used for the construction of model is generally considered as the future landslide area. In this study, all landslides (polygons) were divided into two parts (70% for modeling and 30% for validation). Landslide Density (LD) Index was used to validate the model which is a ratio between the percentage of landslide pixels and the percentage of class pixels in each class on landslide susceptibility map. The calculation result of LDI.

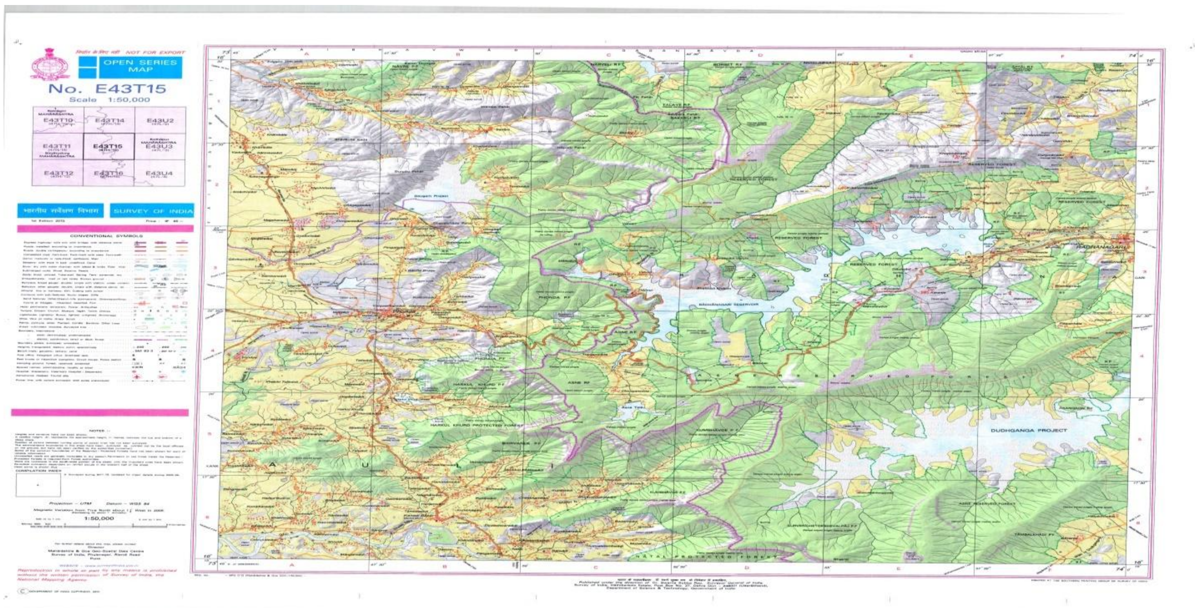
Soil:



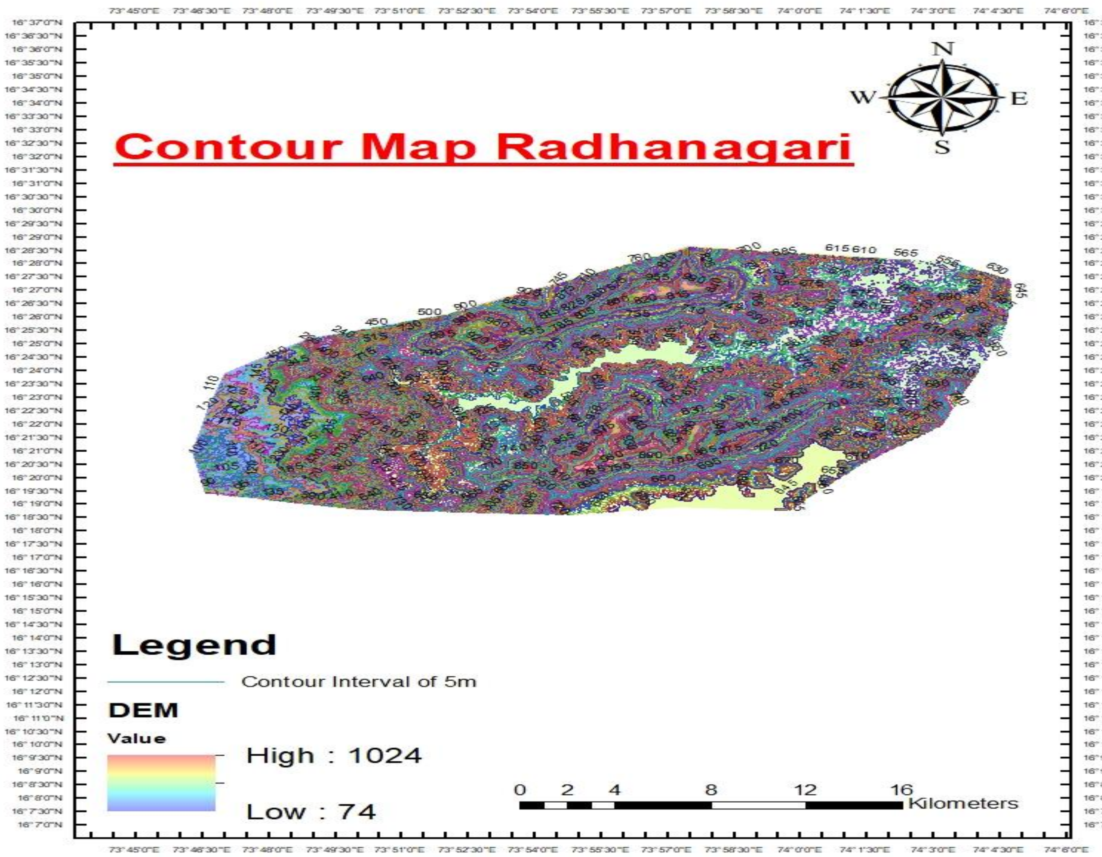
079: Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping escarpments with severe erosion and strong stoniness; associated with shallow somewhat excessively drained, loamy soils with severe erosion and strong stoniness.
049: Shallow, well drained, loamy soils on moderately steeply sloping Sahyadri eastern slopes and narrow valleys with severe erosion; and strong stoniness; associated with shallow, somewhat excessively drained, loamy soils with severe erosion and strong stoniness.

Land use/Land cover:
For the interpretation of false-color composite and preparation of user-friendly land use/land cover, four different years FCCs are downloaded from www.bhuvan.orgwebsite which are clear and without any disturbance of cloud images.



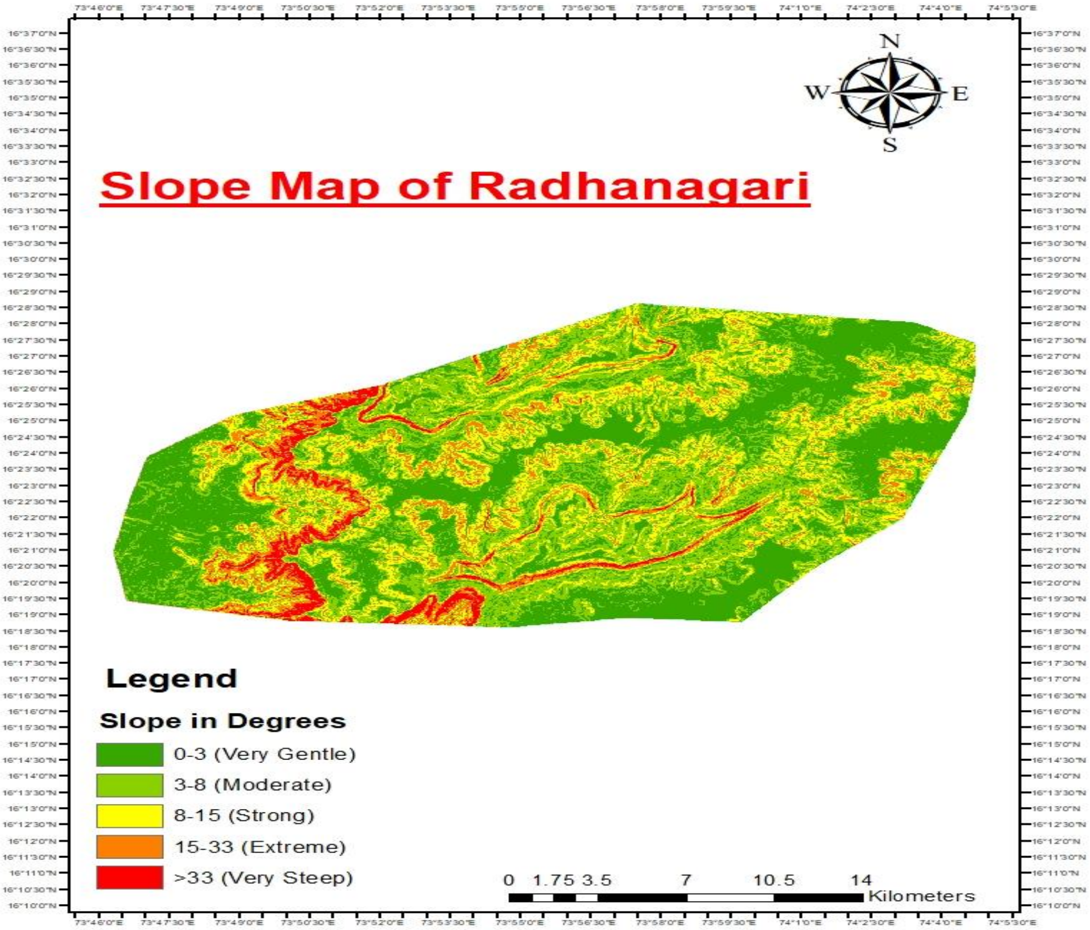


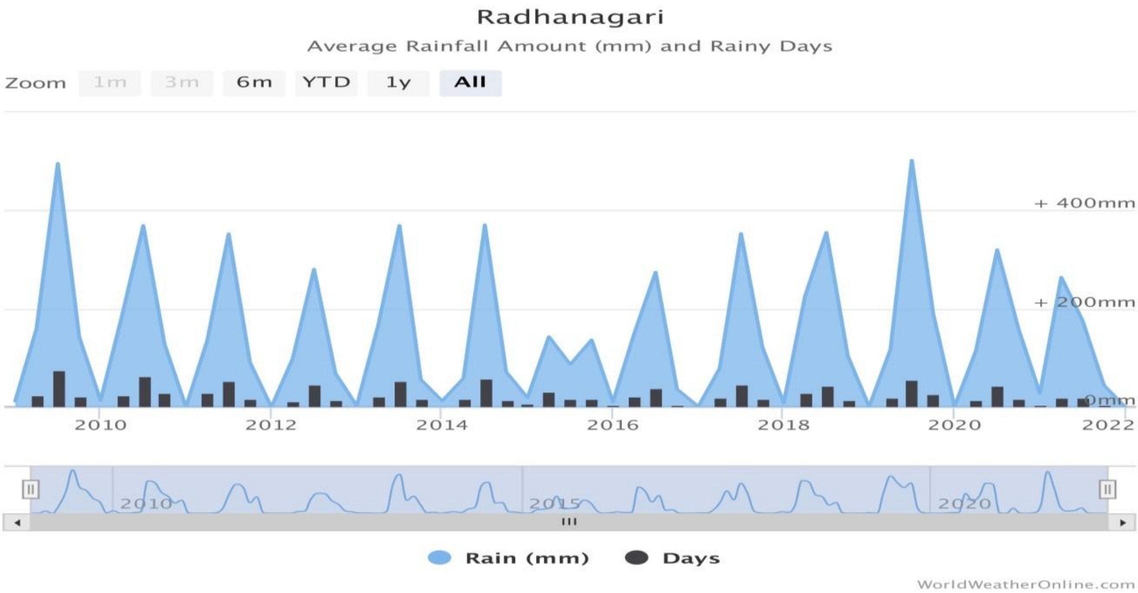
Contour Map:
The DEM has been processed to generate the contours at interval of 30 m of the study area. It gives idea about the undulations of the ground surface. Co



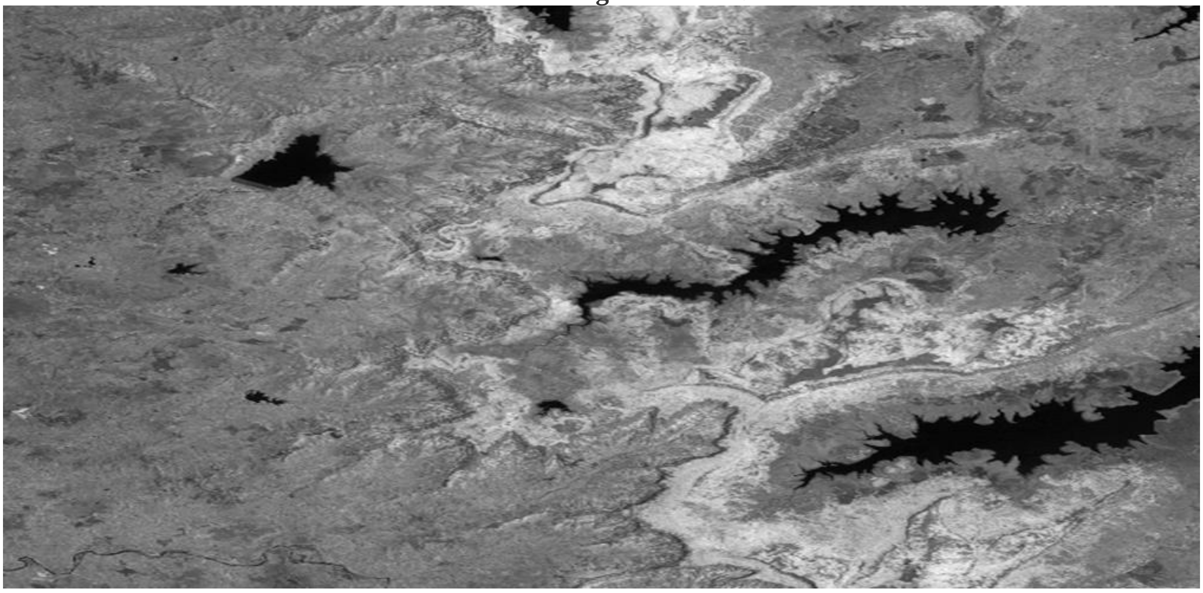
Slope Map:

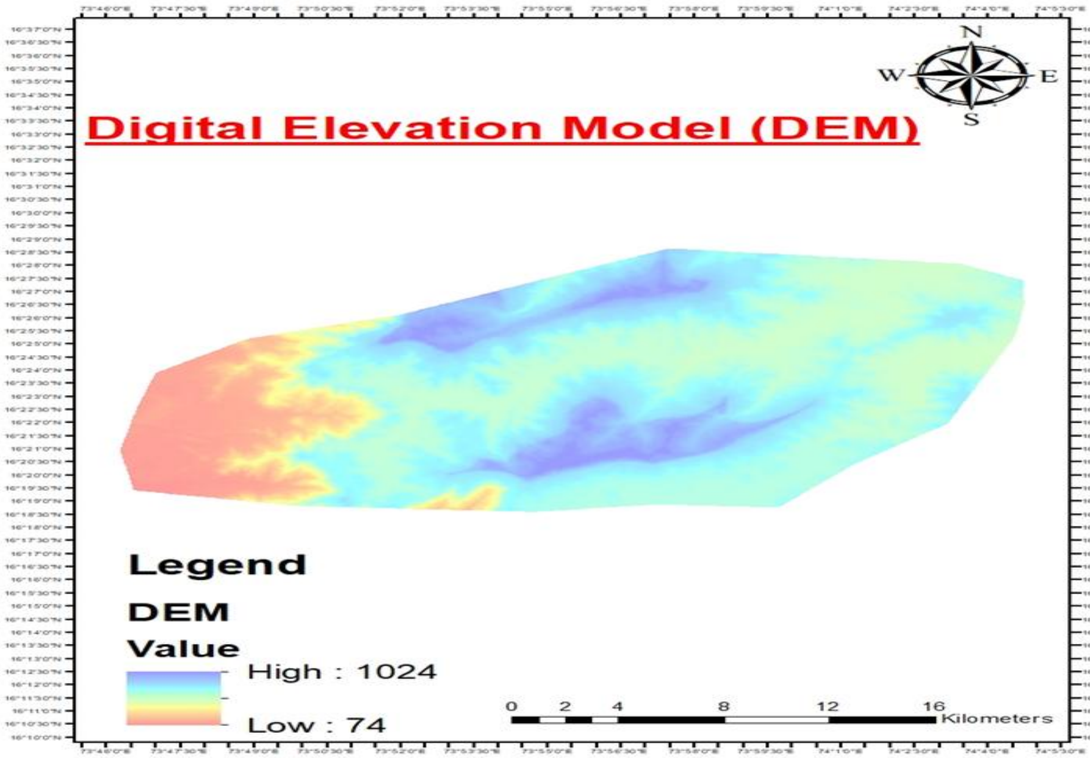
The main parameter of the slope stability analysis is the slope angle, and because the slope angle is directly related to landslides, it is frequently used in preparing landslide hazard zonation maps. The slope map is derived from digital elevation model (DEM). The contour map is frst converted to the DEM and then the slope map is prepared.


Slope Map of Radhanagari
N
W
E
S
Legend
Slope in Degrees
0-3 (Very Gentle)
3-8 (Moderate)
8-15 (Strong)
15-33 (Extreme)
>33 (Very Steep)
0 1.75 3.5 7 10.5 14
Kilometers


Radhanagari
Average Rainfall Amount (mm) and Rainy Days
Zoom 1m 3m 6m YTD 1y All
+ 400mm
+ 200mm
0mm
2010 2012 2014 2016 2018 2020 2022
2010 2015 2020
Rain (mm)
Days
WorldWeatherOnline.com

Satellite Image and DEM:





LITURATURE SURVEY/BACKGROUND

A landslide is the downward movement of rock, debris or earth along the slope. The term "Landslide" encloses five ways of slope movement: falls, slides, spreads, topples and flows. These are further subdivided by as bedrock, debris or earth.

Every landslide has multiple cause slope movement occurs when forces acting down-slope i.e., gravity exceed the strength of the earth-materials that compose the slope. Different factors include sudden increase in factors affecting the down-slope forces and factors which promote or reducing of strength.

H. Shahabi Et.al:, 2012 presented a paper that gives towards landslide susceptibility mapping by remote sensing, data processing and GIS analysis it also used to existing thematic maps Hyun-Joo-Oh Et.al:, 2016 proposed the methods of geotechnical properties of rocks that form the sliding slope. Binli Et.al:, 2021 in his studies evaluate the landslide susceptibility of Hvangyan county of Qinghai by field study, 100 landslide disaster areas in the particular area were selected. He used the information method (IM) model, Frequency Ratio Model and Artificial Neural Network (ANN) to analyze the susceptibility of geological losses.

Fraveen Kumal Et.al:, 2014 started that the satellite images of LandSAT ETMt, IRS, P6, ASTER etc along with important for collecting basic information of various factors such as slope, aspect, relative, relief, drainage density, geology, lithology and land use. Laila FayezEt.al:, 2018, developed Frequency Ratio Model to access the landslide susceptibility in the study area.

Patil Abhijit S. and Panhalkar S.S., 2019proped a paper on Analytic Process for landslide zone in South-Western Ghat of Maharashtra. The objective of this paper was to study different layers of landslide on the basis of degree of potential. Further AHP model is obtained with thirteen thematic layers.

Prasanna Venkatesh, Saranaathan., 2018, involved the study of different systematic maps such as contour, drainage, slope, aspect, curvature, DEM, DTM, drainage density, drainage intensity, geology, lineament, geomorphology, landuse, runoff, buffer maps like road, drainage lineament etc. in CNG ghat section. Satish Deshmukh Et.al:, 2018 present a paper which aimed to quantity sediment yield of Upper Karha Watershed located in Pune District, Maharashtra. In this study, USLE model and RUSLE model is performed by using remote sensing and geographical information system for the sediment yield assessment.

Class	LSI	% Pixels	%Landslide	Landslide Density
Low	2.433-7.91	28.5	7.06	0.248
Moderate	7.91-10.44	27.88	12.27	0.44
High	10.44-15.4	43.66	80.67	1.85

Fig: The performance of the FR model using LD

III. RESULT:

From the calculation, the study area was divided into five zones of relative landslide susceptibility, i.e., very low susceptibility, low susceptibility, moderate susceptibility, high and very high susceptibility of landslides. The high and very high landslide susceptibility regions are where the steeper slope gradients are, which is dominated by dryland agriculture and settlement, latosols type of soil, and are closer to lineaments in which there are higher total rainfall amounts. In addition, Radhanagari higher population density (8985 people/km^2) and the reactional area of BogorRadhanagari regency are located mostly near or on slopes hosted in volcanic-derived lithologies (near Mount Salak, Mount Pangrango, and Mount Gede, located at Sukabumi and Cianjur regency). This shows the area is divided into very low to moderate landslide susceptibility in the northern part of this region (low plain landscape type) and moderate to high susceptibility of landslides in the southern part of this region (highland landscape type).

IV. CONCLUSION

In this article brief explanation on the term landslide has been studied. The various hazardous impact of landslides on environment where studied. Landslide's location using aerial photo and satellite image where detected. An efficient environment for analyzing and displaying results with powerful set of tools for collecting, storing, retrieving transforming and displaying spatial data from the real world. On the basis of above research conclusion is made that the 'Identification of Landslide Susceptible Zones Using GIS' is effective method to identify landslide prone areas.

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