Analysis of Landslide Hazard Zones Using GIS and Remote Sensing in Western Ghat Maharashtra (Chandoli Region)

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Abstract: Landslides are one of the most dangerous natural disasters in mountainous areas. The area around Chandoli affected by landslides is selected for the study purpose. This area falls into four districts of Maharashtra namely - Satara, Sangli, Kolhapur, and Ratnagiri. Landsat8, Google Earth, Google Maps, and other satellite images, as well as Survey of India (SOI) topographical sheets, serve as the foundation for obtaining baseline information on different metrics such asNDVI slope, relative relief, drainage density, and geology/lithology. The purpose of this research is to understand the importance of mapping geological lineaments and landscape characteristics including streams, slopes, and aspects. Rainfall is one of the primary causes of landslides. Any corrective action must include one or both of the following characteristics. Thus, landslide hotspots will be identified using GIS and remote sensing. The pictures for the analysis were collected in FEBRUARY 2022, and the analysis will be completed in May and June.

Index Terms: Landslide, GIS, Remote Sensing, Mapping, Survey of India, etc.

I. INTRODUCTION

A landslide, also known as a landslip or mudslide, is a type of mass wasting that involves a variety of ground motions such as rock falls, deep slope collapse, and shallow debris flows. Landslides are a major concern in virtually every area of the world because they create economic or social damage to private and public property. Natural calamities have shown the devastating potential of rapid mass movements during a landslide, which cost lives and inflict significant damage to property and infrastructure on an annual basis. Remote Sensing (RS) and Geographic Information Systems (GIS) play critical roles in the effective mitigation and management of disasters, providing a framework for monitoring, evaluation, detecting deficiencies, and suggesting suitable disaster management methods. RS and GIS have become important tools in geology for predicting and estimating natural hazards. GIS may be used to build hazard analysis models that can be utilized to save lives and property, ranging from better monitoring of prospective crises to better monitoring of potential disasters. Although natural disasters have increased dramatically and frequently over the past few decades, there has been a tremendous increase in the power of technology to mitigate them. As a result, the economic damage caused by natural disasters is growing with time. These human settlement disturbances, new urbanism, and engineering contractions consume a portion of the natural budget. Hazard assessment is required to identify any examined area with a degree of hazard, which may then be used for land-use planning. Chandoli region in Maharashtra is divided by the arid climate, low population density, natural vegetation, low soil conditions, diverse geomorphology, and slope gradient. Any sustainable development strategy in the Chandoli region (western ghat) faces significant environmental challenges like landslides, shortage of water supplies, flash floods, and groundwater contamination. Furthermore, hazardous behaviors brought about by the quick rate of development may endanger the area's natural and cultural assets indefinitely. Chandoli and its surrounding area have been selected as a pilot study on district natural hazards and planning for the entire Western Ghat region. Landslide risks represent a serious threat to life, property, and infrastructure, and can constitute a major impediment to the area's growth.

II. STUDY AREA

The region under inquiry is one of Kolhapur's most significant National Parks and Tiger Reserves (Chandoli). The researched region is located between latitudes 17°37'35" N and longitudes 73°54'00" E, and it covers an area of about 1385.82 square kilometers. It has an elevation of 582 meters on average (1909 feet). The site under consideration, Chandoli, has arid to semi-arid climatic characteristics defined by a significant downpour, less summer, and huge winter. The vast bulk of the rainfall is in the form of massive showers that linger for a long period. In the study area lies the Chandoli dam, which was erected over the Warna River. The research area is in the Sahyadri Mountain range, which has a lot of rain. As a result, the chance of a mudslide in the study area rises.

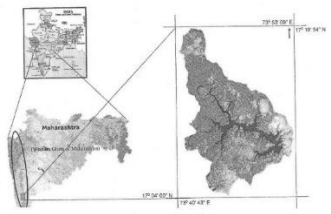

Fig 1: Location Map.

III. MATERIALS AND METHODS

In the current study, LHZ methodology is used to identify the type and degree of risk by studying possible hazards and evaluating existing vulnerability situations that might represent a potential danger or harm to people, property, livelihoods, and the environment on which they rely. This part discusses data collecting and data processing techniques, the approach for preparing distinct thematic maps, and the criteria used to remove and identify the LHZ of the research region using image processing and GIS. Several materials, methodologies, and mapping approaches were utilized in the current study to create the environmental LHZ of Patan, Satara, Maharashtra, India. Various forms of data have been utilized, including RS, geo-referenced data, tabular data, and other auxiliary geological data.

In the current study, GIS methods were used to represent the study area's LHZ susceptibility. The main and secondary data were transformed into digital layers before being overlaid and integrated to create the LHZ map. GIS capabilities like manipulation, combination, overlay, integration, and reattribution have been utilized frequently with GIS systems to create the necessary logical procedures. Thematic information was extracted and produced using improved ETM+7 pictures, geo-reference, and other auxiliary geological data as characteristics of points, lines, and polygons coverages, and was then assembled into an expandable database.

Spatial Database Generation For Analysis

Several variables and criteria, including drainage, contour, slope, aspect, height elevation, and land use/land cover, were established for LHZ in the current study as the following.

Establishment of Analysis Maps

DEM provides a novel way of providing information on landslides. In the current investigation, DEM files are created using ARC/GIS software. The DEM reflected spatial altitude variation, and it was utilized to produce a slope, stream, and NDVI maps. The slope is a measure of the change in height over time. The slope is an important metric to consider when considering stability. It is the first derivative of elevation, with each pixel representing the slope angle at a specific location. Shear stress in soil and other unconsolidated material typically increases as the slope angle increases.

Digital Elevation Model

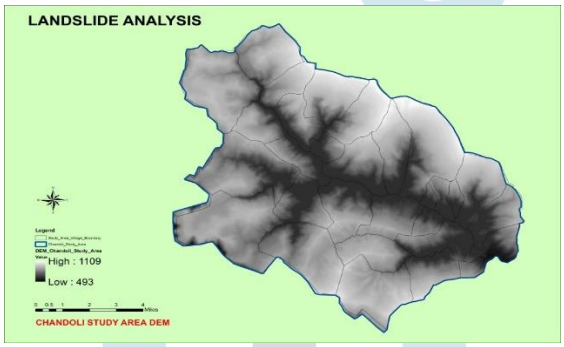

Fig 2: DEM

Slope Map of The Study Area

Although it is directly connected to landslides, the slope angle is the most important element in landslide susceptibility mapping. Using ArcGIS V10.8.3 software, the slope map was categorized into nine groups based on the conventional categorization for hill land.

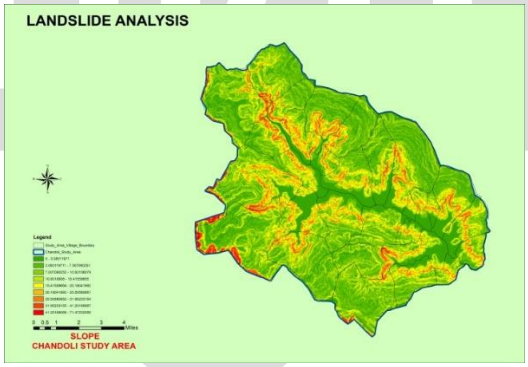

Fig 3: Slope

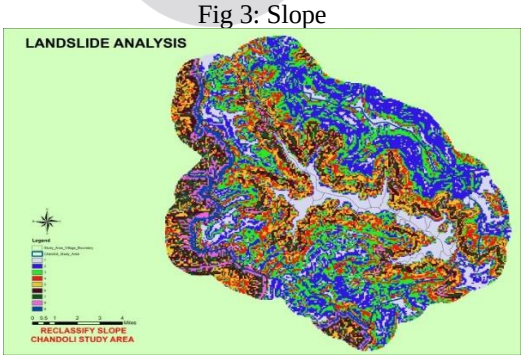

Fig 4: Reclassify Slope

Stream Map of The Study Area

The proximity of streams near landslides is an important regulating element since it can generate major erosion processes. Streams of second or higher order, according to Strahler's categorization, were chosen and treated by establishing a 50 m buffer zone.

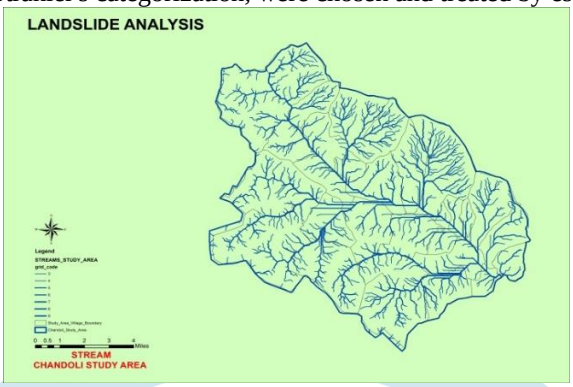

Fig 5: Stream

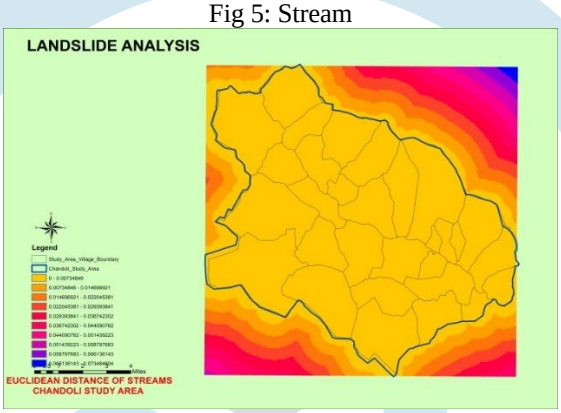

Fig 6: Reclassify Euclidean Stream

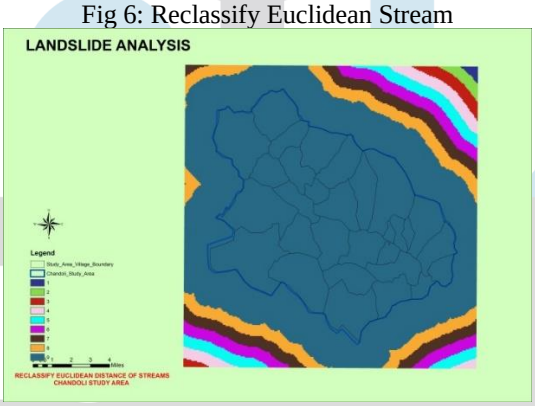

Fig 7: Euclidean Distance

NDVI Map of Study Area

The NDVI (Normalized Difference Vegetation Index) is a flexible vegetation index that may be used to assess the vegetation and the dynamic of vegetation coverage change. Over the years, this index has been examined and assessed with several satellites, altering its calculus technique in response to the number and kind of bands on the satellite.

In Landsat 8, NDVI = (Band 5 – Band 4) / (Band 5 + Band 4).

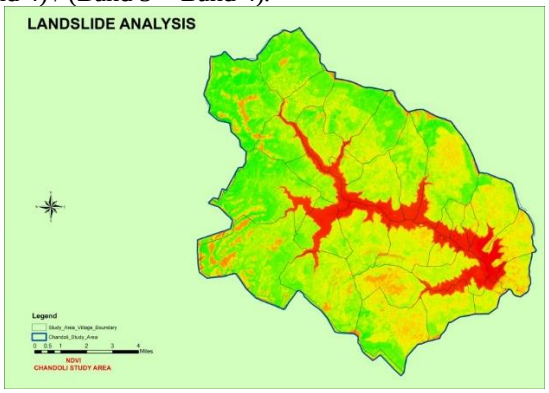

Fig 8: NDVI Map

Final Output Map (Landslide Hotspot Zonation Map)

The final output map image shows the landslide hotspots in the Chandoli area. All hotspots are present in the hilly areas and near the slope of stream bodies. The villageshaving hotspots were mitigated as a procedure of hazard management. The image shows the landslide hotspots in the study, area-wise. The hotspots marked on the map are the most probable zones of the landslides. These hotspots are present in the Chandoli Study Area and also very much near the stream area, and the Chandoli dam. Most of the hotspots show the presence of water bodies in the nearby area.

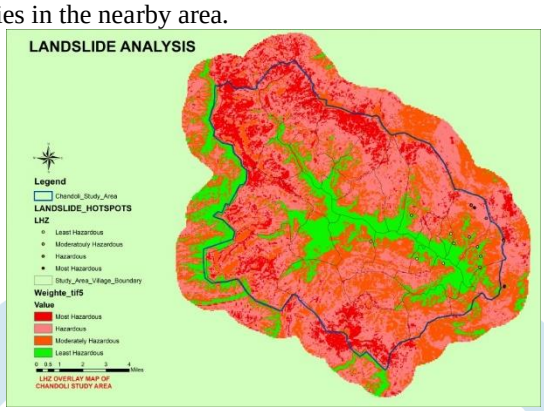

Fig 9: Final Output Map

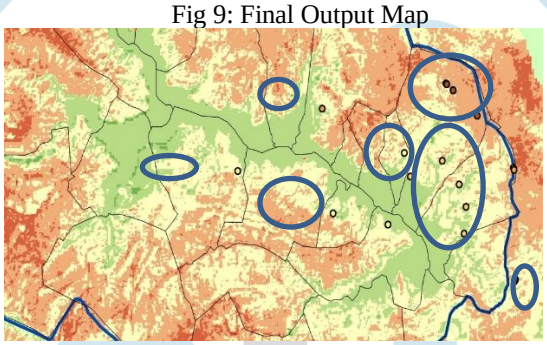

Fig 10: Landslide Hotspot Highlight Map

IV. CONCLUSION

Landslide Hazard Zonation (LHZ) scenario map of the study area, Results from a recent study focused on the identification of critical LHZ in the Chandoli Region, Western Ghat, Maharashtra and surroundings area, Sangli, Satara, Kolhapur, and Ratnagiri Dist. This also highlights the importance of multidisciplinary studies of landslide hazards, combining subjects as diverse as geology and geomorphology, RS, and GIS. The following specific conclusions are drawn from the study:

1. The area is classified into four parts

a. Low b. medium c. High d. Very high

2. Most of the identified hotspots are on the steep slope in hilly Regions.
3. The analysis done on the satellite image LANDSAT-8 dated February 2021 and the analysis done in June 2021 we got the information about the various landslides occurred in Chandoli Region, Western Ghat Maharashtra, India in July 2022 so that we visited the Landslide location, the location of spots identified and actual location of landslide are matched.
4. Thus in this present work, we can identify the probability locations of the landslides with the use of various maps in the Arc-GIS software.

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