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# Using GIS in a Landslide-Prone Area

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**Abstract:** *A computer-based tool for mapping and evaluating geographical phenomena and occurrences on Earth is the geographic information system (GIS). Common database integration is a feature of GIS. It has functions like statistical analysis and inquiry. This feature sets GIS apart from other information systems and makes it useful for a variety of public and commercial businesses in terms of forecasting results, planning strategies, and explaining occurrences. Landslides, watershed management, urban planning, water resource engineering, and other areas are among the many uses of GIS in civil engineering. One of the natural disasters that involves the movement of rock, debris, and soil as a result of slope collapse and gravity is a landslide. There are fundamental causal factors that only determine the severity and degree of landslide episodes, which might vary. Water always plays a part in social movements. Slope collapse is frequently caused by human activities in addition to natural causes. It results in property damage, fatalities, and damage to buildings. The use of GIS for landslides is covered in this work. In order to prevent landslides, preventive measures are also recommended*

**Keywords:** GIS, landslide, civil, engineering, slope, failure

## I. INTRODUCTION

The fundamental area of engineering that has many applications in people's daily lives is civil engineering. One computer-based technology that is helpful in many different industries is the Geographic Information System, or GIS. It has the ability to store data and process it to produce an output. Geotechnical engineering, watershed management, pollution monitoring, transportation management, architectural planning, and other areas of civil engineering all benefit from the use of GIS. One of the natural disasters that involves the movement of rock, debris, and soil as a result of slope collapse and gravity is a landslide. There are fundamental causal factors that only determine the severity and degree of landslide episodes, which might vary. Water always plays a part in social movements. Slope collapse is frequently caused by human activities in addition to natural causes. It results in property damage, fatalities, and damage to buildings. According to Van Westen et al. (2006), they are often separate processes that can happen frequently even if they may not be particularly substantial on their own.

## II. LITERATURE REVIEW

According to Varnes (1984), landslide hazard is the likelihood that landslides will occur inside a particular area and over a certain time period. Cruden (1991) defined a landslide as the movement of a mass of soil, rock, or debris down a slope. Scheidegger (1994) defined it as the likelihood that a situation that is relatively steady might change suddenly. The size, volume, and velocity of the anticipated landslide should be included in the definition, according to Guzzetti et al. (1999). Sharma (1996) underlined that the location and magnitude of a landslide should serve as the foundation for a thorough hazard assessment and mapping.

Landslides are caused by many activities, such as falling, sliding, and flowing from one location to another, that cause materials made of rocks, soils, manmade fills, or a mix of these elements to move downhill and outward along surfaces of separation. Even while landslides are mostly associated with hilly terrain, they can also happen in places where open pit mining, surface excavation for structures, and roadways are conducted. The materials may move by slipping, spreading, toppling, dropping, or flowing. While some landslides happen quickly—in a matter of seconds—others may take hours, weeks, or even longer. Rainfall, earthquakes, geology, gravity, weather, groundwater, wave action, and human activity are all elements that can cause landslides. Landslides can happen in places with little relief, even though they usually happen on steep hills. Slope failures related to quarries and open-pit mining, cut-and-fill failures that may accompany construction and highway excavations, and ground collapse of river bluffs can all result in landslides. The word "landslide" refers to a broad range of processes that cause rock, soil, artificial fill, or a mix of these to move outward and downward and produce slopes. The materials can move by slipping, spreading, toppling, collapsing, or flowing. The sorts of material used and the way they travel may be used to distinguish between the different types of landslides. Table 1 displays a categorization scheme based on these criteria. Additional factors including the pace of movement and the amount of water, air, or ice in the landslide debris are included in other categorization schemes.

**Table -1:** Landslide types and the condensed form of Varnes' slope movement categorization (Varnes 1978)

| Type of movement | | Type of materials | | |
|---|---|---|---|---|
| | | Bedrock | Engineering soils | |
| | | | Predominantly coarse | Predominantly Fine |
| Falls | | Rock Fall | Debris fall | Earth fall |
| Topples | | Rock Topple | Debris topple | Earth topple |
| Slides | Rotational Translational | Rock slide | Debris slide | Earth slide |
| Lateral spreads | | Rock spread | Debris spread | Earth spread |
| Flows | | Rock flows (deep creep) | Debris flows | Earth flow |
| | | | (soil creep) | |
| Complex movements | | Combination of two or more principal types of movement | | |

Landslides occur regularly in India's hilly regions. Landslides can be caused by a variety of factors, including human involvement, rainfall, earthquakes, and gravity. India is separated into many zones according to landslides.

• The Eastern and North-eastern Himalayas (in the states of West Bengal, Sikkim, and Arunachal Pradesh);
• The Western Himalayas (in the states of Uttar Pradesh, Uttaranchal, Himachal Pradesh, and Jammu & Kashmir)
• The Naga-Arakkan mountain range, which includes the states of Tripura, Manipur, Mizoram, and Nagaland.
• The Meghalaya plateau in northeastern India; the Western Ghats area, which includes the Nilgiris (in the states of Maharashtra, Goa, Karnataka, Kerala, and Tamil Nadu); and the Peninsular India Plateau boundaries.

Some of the major landslides that took place in different parts of India are given in Table 2.

**Table 2**: India's major landslides

| S.N. | Date | Location | Impact |
|---|---|---|---|
| 1 | July1984 | Kerala | 14Killed |
| 2 | June1985 | Kumpanpara,Kerala | 9Killed |
| 3 | October1990 | Nilgiris | 36 people killed and several injured. Several buildings and communication network damaged |
| 4 | July1991 | Kappikalam, Kerala | 11killed |
| 5 | July1991 | Assam | 300peoplekilled,roadandbuildings Damaged |
| 6 | November1992 | Nilgiris | Road network and buildings damaged, Rs.5 million damage estimate |
| 7 | June1993 | Aizawal | 4 persons were buried |
| 8 | July1993 | Itanagar | 25 people buried alive,2 km road damaged |
| 9 | August1993 | Kalimpong,WB | 40 people killed, heavy loss of property |

## III. METHODOLOGY AND STUDY AREA

A computer-based tool is the GIS. It is employed in the mapping and analysis of geographical phenomena and events that take place on Earth. Soil characteristics, photos, and topo sheets are the data needed for analysis. One feature of GIS is the ability to integrate a shared database. It encompasses functions like statistical analysis and inquiry. GIS

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differs from other information systems as a result. It is helpful and important to a variety of public and commercial companies for strategy development, result prediction, and event explanation.

There are four primary functional subsystems of GIS. They are:

a. Data input system

b. Data storage and retrieval subsystem

c. Data manipulation and analysis subsystem

d. Data output and display subsystem

GIS uses its own hardware to function. GIS relies heavily on data. Spatial data may be integrated with other available data resources with the help of GIS. One important feature that GIS offers is the ability to integrate tabular data stored in a DBMS with geographical data. People who oversee the GIS system play a crucial role.

**The components of GIS are:**

- Data
- Software
- Hardware
- Methods and Procedures
- People

The GIS components are shown in Figure 1

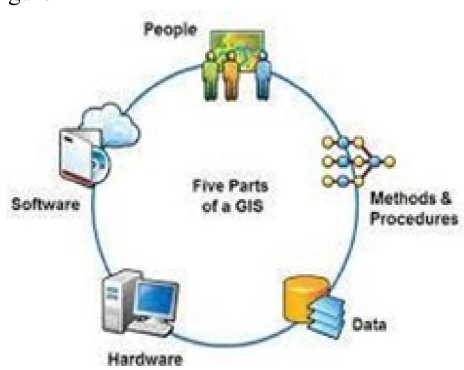


**Figure 1:**GIS Components

**The approach includes:**

a) Literature study on the causes and remedies of landslides.

b) Gathering geotechnical and geographical data for the necessary research.

c) To create thematic maps utilizing satellite imagery, District Resource Maps, and Survey of India (SOI) Toposheets.

d) To gather the sample in order to ascertain its geotechnical characteristics.

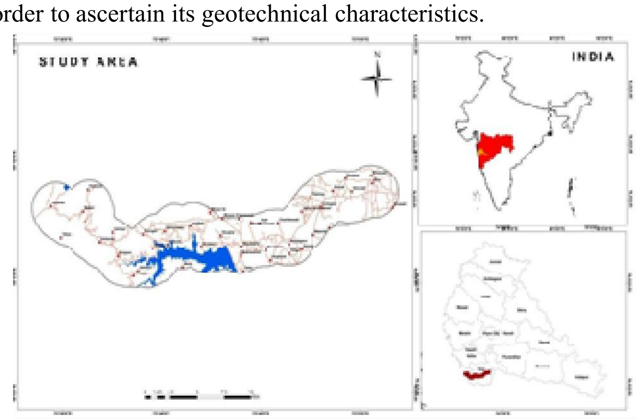


**Figure 2:** Location Map of the study area- VarandhaGhat

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There are hills, valleys, woods, farms, settlements, and other features in the VarandhaGhat region. With latitudes 18° 04′ 34.77″N to 18° 09′ 46.37″ N and longitudes 73° 33′ 29.13″E to 73° 51′ 54.81″E, it is situated in the Bhor and Velhataluka of the Pune district. Figure 2's location map of the research region was created using Survey of India toposheets E 43 H/12 and E43 H/16, which have a scale of 1:50,000. IV.

## IV. RESULT AND DISCUSSION

Various themed maps are created using the base map and remote sensing data. Contour and drainage maps are created by digitizing the catchment area border contours and drainage on the base map. Georeferencing was done on the satellite data. Using controlled points that were already created on the base map, scanned maps were geo-referenced in QGIS. Following correction, the four control points in the upper left, lower right, and lower right corners of the map were given the appropriate latitude and longitude values. QGIS software was then used to turn the points into a polyconic projection scheme. QGIS software was used to digitize scanned maps on-screen, and any problems that arose during the digitization process were fixed with the proper editing. Following completion, error-free coverage characteristics were allocated to various land use, drainage, and soil groups, among others.

Altitude data can be represented digitally in a GIS system. DEM is the name of this system. It is therefore a computational depiction of the relief of the planet. A DEM is a three-dimensional depiction of a terrain's surface. Triangulated irregular networks, contour lines, conventional grids, and dispersed data points are among the several forms (Gopi et al., 2007). Numerous fields of study, including geology, geomorphology, landscape, education, and health, can use it as a key input. For the DEM, topographic maps with contours are necessary. The topographic map is transformed into a digital version during the scanning procedure. Typically, it is included into the GIS database. Figure 3 displays the research area's DEM.

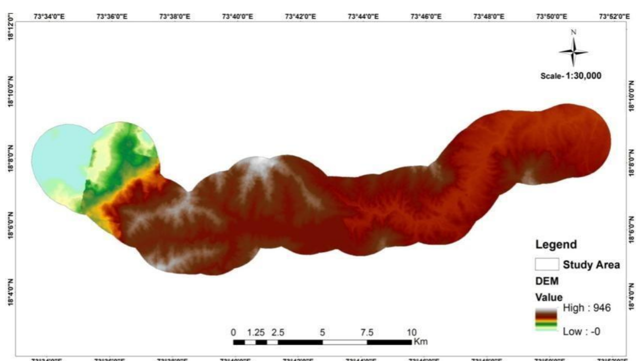


**Figure 3:** Digital Elevation Model of study area

In order to determine the locations of villages, landslides, soil types, rock types, land use, and land cover, a comprehensive field survey was carried out in the VarandhaGhat using GPS. We spoke with residents of these communities and learned about landslides. It was determined which rocks, minerals, and geologic formations were predominant. It was observed that there were rivers, streams, bodies of water, flora, etc. We looked at historical rainfall, land use, and landslide data. Residents and local government agencies also provide information.

After observing the soil samples during the field visits, we were able to determine the kind of soil. We have seen the kind of rock, the flora, erosion, the safety measures put in place to prevent landslides, etc.

Table 3: Field Observations of the Varandha Ghat

| S. N. | Location | Latitude/ Longitude/ Elevation | Slope/ Height/ Length | Type of Vegetation | Previous landslide | Weathering condition of soil/rock |
|---|---|---|---|---|---|---|
| 1 | Apti | 18° 10' 48" N 73° 40' 08"E 740 m | S-80° H-10m L-35m | Scanty | Yes | Moderate |
| 2 | Venupuri Bus Stop | 18°06'24" N 73° 42' 11"E 740 m | S-80° H-8m L-17m | Moderate | Yes | Moderately weathered |
| 3 | Venupri bridge | 18°06'46" N 73° 42' 01"E 720 m | S-75° H-10m L-22m | Moderate | Yes | Highly weathered |
| 4 | Ayush Garden | 18°06'43" N 73° 40' 55"E 742 m | S-80° H-18m L-90m | Moderate | Yes | Highly weathered |
| 5 | Hirdoshi Bridge | 18°07'02" N 73° 40' 39"E 704 m | S-85° H-14m L-23m | Moderate | Yes | Fresh |

The parameters of the soil samples were ascertained in the laboratory after they were taken from the location. The stability of a slope is computed using these characteristics. Remedial actions might be recommended based on the safety factor.

Table 4: Typical Properties of soil mass and Factor of Safety at different locations for VarandhaGhat

| S. N. | Description | Location-1 | Location -2 | Location -3 | Location -4 | Location -5 |
|---|---|---|---|---|---|---|
| 1 | Dry (kN/m³) | 13.20 | 12.08 | 12.62 | 12.13 | 12.25 |
| 2 | Bulk (kN/m³) | 15.70 | 13.80 | 14.10 | 14.25 | 14.35 |
| 3 | Specific Gravity | 2.30 | 2.30 | 2.55 | 2.35 | 2.35 |
| 4 | O.M.C. (%) | 18.10 | 17.20 | 16.20 | 16.10 | 18.20 |
| 5 | M.D.D. (kN/m³) | 15.00 | 14.10 | 13.90 | 13.65 | 13.95 |
| 6 | Coefficient of Curvature | 2.85 | 2.80 | 2.06 | 2.62 | 1.62 |
| 7 | Uniformity Coefficient | 7.60 | 6.65 | 17.55 | 10.10 | 8.70 |
| 8 | Direct Shear Test - $\phi^\circ$ | 33.99 | 35.60 | 38.80 | 34.20 | 33.25 |
| 9 | Direct Shear Test-C kPa | 26.50 | 26.35 | 35.85 | 25.45 | 26.20 |
| 10 | Angle in degrees | 80° | 80° | 75° | 80° | 85° |
| 11 | Factor of Safety | 1.57 | 2.22 | 2.37 | 1.04 | 1.18 |

## V. CONCLUSION

The research area's theme maps were created. Along the State Highway that connects Bhor and Mahad, several areas have been identified as being at risk of landslides. A tool for covering a wider area for examination is the GIS. The landslide-prone areas along the Bhor to Mahad State Highway are depicted in Figure 4. Remedial actions were also recommended to prevent landslide-related property and human casualties.

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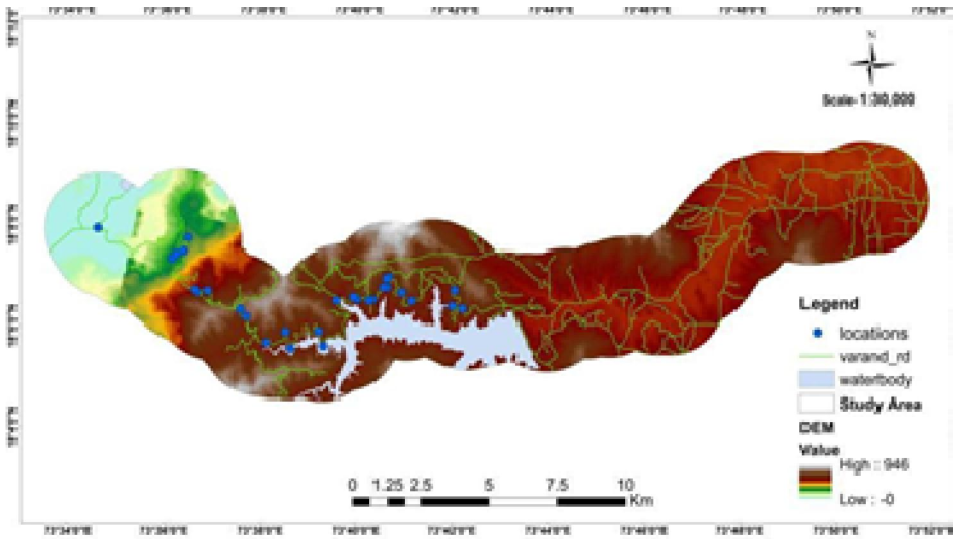


**Figure 4**: Location of the study points of Varandha Ghat

**Landslide Prevention Measures:** A variety of techniques are employed to stop landslides. Avoid the landslide-prone area as much as you can.

Before buying any land or building, the opinion of a geologist or geotechnical engineer should be sought. Some corrective actions to prevent landslides are listed below.

**a) Enhancing surface and subsurface drainage:** Since water is a major contributing factor to landslides, a landslide-prone slope's stability can be raised by enhancing surface and subsurface drainage at the location. Water should be directed in a drainage ditch to the slope's base in order to drain surface water away from the landslide-prone area. To prevent causing a landslide next to the site, the water should be drained carefully. On the landslide-prone slope, surface water shouldn't be let to accumulate.

**b) Slope Vegetation:** Vegetating the slope is one of the simplest ways to prevent landslides along it. If the movement hasn't started yet or the slope isn't too steep, this landslide prevention technique can be used. One can either employ a landscaper to vegetate the slope or do it themselves by planting groundcover.

**c) Retaining walls:**

To withstand the lateral pressure of soil, a strong, well-designed retaining should be constructed from durable materials like steel, stone, brick, or masonry. A well-designed drainage system behind the wall contributes to the wall's increased stability.

**d) Diverting Debris Pathways:** By creating pathways to redirect debris, you can stop landslides on your property. Retaining walls can be used to build these routes. However, you are responsible for any damage if this debris flow ends up on your neighbor's property because of the wall construction

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