JETIR.ORG | ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

"Landslide Susceptibility Mapping Using GIS and AHP For Dhanivali Village"

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Abstract—The present work including inventory mapping was conducted to establish landslide susceptibility map using GIS-based spatial multicriteria approach. The eight parameters are considered for present study, these parameters are thoroughly analysis from AHP process by allocating ratings for getting best possible pair wise comparison of each parameter and Weight for each factor is assigned using Weighted overlay analysis (WOA) depending on its influence on the landslide occurrence. The landslide susceptibility map was derived using weighted overlay method and categorized into three susceptible classes namely, low (L), moderate (M), high (H). For overlay analysis weighted overlay analysis tool used to combine all causative parameters. study is explained that about 18% land area of the study region is vulnerable or high to very high landslide hazards at side slope parts of hilly regions may slide highly. whereas about 64% and 18% land area come under Moderate and Low hazard zone respectively.
Keywords:Geo-Graphic Information System (GIS), Analytical Hierarchy Process (AHP), Weighted overlay analysis (WOA).

1.INTRODUCTION

A:**IntroductiontoLandslide**:
A large quantity of rock, soil, or other debris moving rapidly down a slope is called a landslip orlandslide.These events can be triggered by a variety of factors, including heavy rainfall, earthquakes, volcanic eruptions, and human activities such as construction or deforestation.
The purpose of this study is to compare the use of open data versus local data for analyzing landslide susceptibility. The comparison will focus on Dhanivali village in Bhor taluka, located in Pune District. To ensure the robustness of the analysis, the entire region will subsequently be analyzed using openly available data. Utilizing open data for landslide susceptibility mapping will facilitate spatiotemporal analysis, especially in regions with limited data availability. Moreover, understanding the importance of each criterion may enhance the accuracy of future studies.

B :**Materials and methods:**
B1: Study Area:
Dhanivali village is situated in Bhor taluka within the Pune district of Maharashtra, India. The region generally experiences a tropical climate, with hot summers and mild winters. The terrain around Dhanivali is predominantly hilly, forming part of the Western Ghats, which are known for their picturesque landscapes and natural beauty. The area is particularly lush and green during the monsoon season, receiving ample rainfall. Additionally, being part of the Western Ghats, Dhanivali and its surroundings are likely to have rich biodiversity, featuring various species of flora and fauna that are endemic to the region.
Dhanavali village, located in Bhor taluka of Pune district, is situated on hill slopes and is surrounded by hills with natural waterfalls flowing along its two edges. To a visitor, the village resembles Irshalwadi, where a recent landslide resulted in the loss of 27 lives and left 47 people missing. "The landslide in Malin village occurred a few years ago, followed by the one in Irshalwadi. Given its similar geographical conditions, Dhanavali village could potentially be the next." Hence, these area is selected.

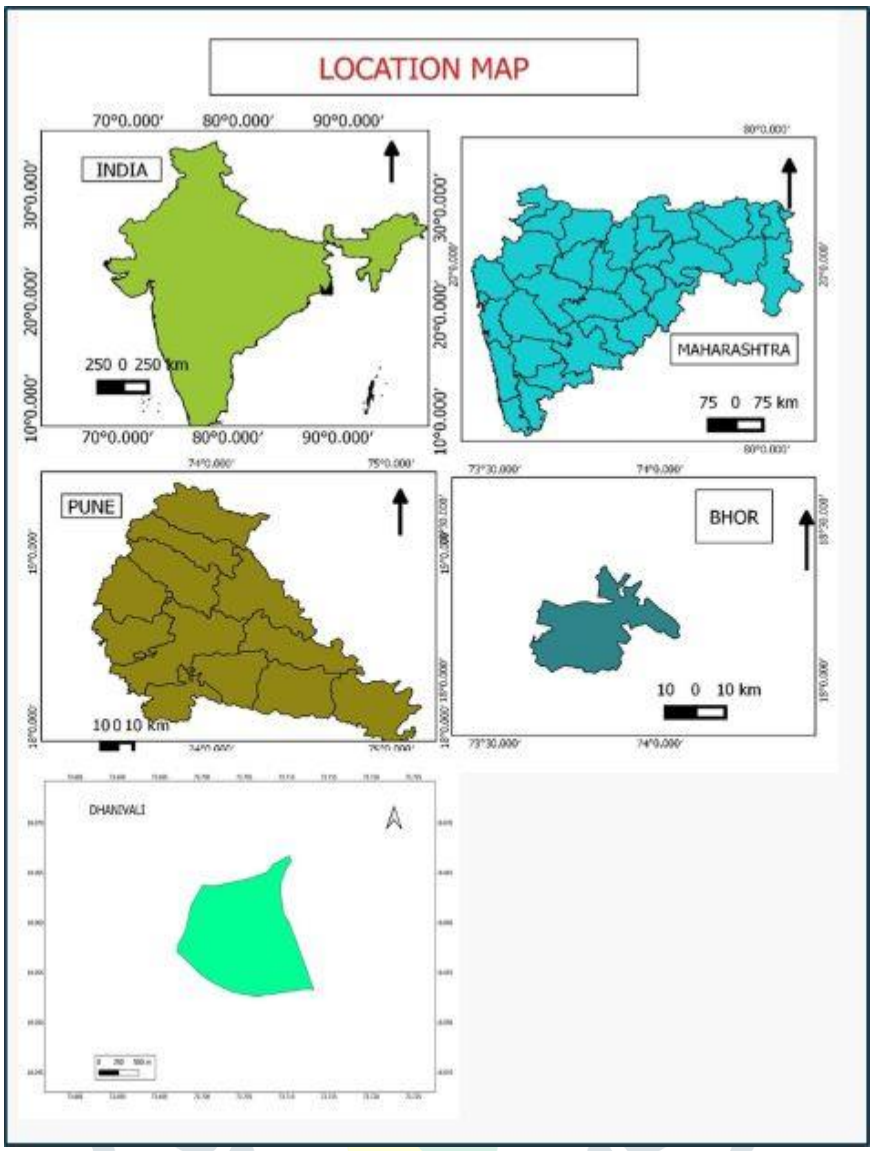

Fig:1.1. Location map of Dhanivali

B2: THEMATIC MAPS :

- **Rainfall:**

Rainwater soaks into the earth, causing the soil to become saturated. The soil becomes weaker and less cohesive as it becomes wet, which increases the likelihood of collapse. Landslides are caused by the increasing water content because it reduces the frictional resistance between soil particles. The earth becomes saturated with rainwater when it seeps into it. When the soil gets wet, it loses strength and cohesiveness and becomes more likely to collapse. Increasing water content causes landslides because it lessens the frictional barrier between soil particles.

- **Slope:**

An important consideration in landslip analysis is slope. Landslides are more likely to occur as the slope rises. Since gravitational shear stress in colluviums and residual soils increases with increasing slope gradient, slope is thought to be another important element in the occurrence of landslides. The digital elevation model (DEM) is the source of the slope gradient, which is the first derivative of elevation. Generally speaking, flat ground is found in small coastal regions or along gullies, while natural slopes are steep. Because slope angle and landslides are directly correlated, slope angle is important for mapping landslides.

- **Flow direction:**

A map of flow direction shows the natural course that water would take when it descends. Every point on the map represents the direction in which water would flow; normally, water moves from higher elevations to lower elevations.

- **Hill shade:**

Realistic landscape views are produced via hill shading, which converts two-dimensional surfaces into three-dimensional representations. When the light source is positioned to the northwest, this technique creates the illusion of artificial lighting.

- **Drainage Density:**

The drainage density provides information on the water flow in the research area. The probability of landslides increases with increasing distance from the drainage line. Given that terracing compromises slope stability, the majority of the watershed is classified as a high-density region. The physical makeup of the surface and subsurface is reflected in a landscape's drainage pattern. The proximity or spacing of stream channels is indicated by drainage density, and the density of these rivers and streams has a major influence on the occurrence of landslides. Near river valleys, landslides are common, mostly because of the steepness brought on by river erosion.

- **Soil Map:**

A soil map is a geographical representation that shows the diversity of soil types and properties. The study area is covered by Nd type soil, known as District Nitrosols. Nitrosols, typically rich in nitrogen, are prone to contributing to landslides due to their characteristics. These soils have high porosity and low cohesion, making them susceptible to erosion, especially during heavy rainfall or when destabilized by human activities such as construction. This erosion can weaken the soil structure, increasing the risk of landslides, particularly on slopes.

- **Geology:**

The Deccan Traps, consisting of massive volcanic rock, can influence landslides due to their topography and composition. The steep slopes and loose, fractured rocks in the Deccan Traps can make the area prone to landslides, especially during heavy rainfall or seismic activity. The volcanic activity that formed the traps also created weaknesses in the rock layers, making them more susceptible to erosion and slope failure.

- **Geomorphology:**

Geomorphology consist of three layers the Plateau top, the StrOri Highly dissected upper plateau and Pediment.. A plateau top might have different geological layers, some of which could be more prone to erosion or instability. The highly dissected upper plateau indicates a landscape with numerous valleys and ridges, which can also influence the stability of slopes. Additionally, a pediment, which is a gently sloping erosion surface at the base of a steep slope, can contribute to instability if it's composed of loose, unconsolidated material.

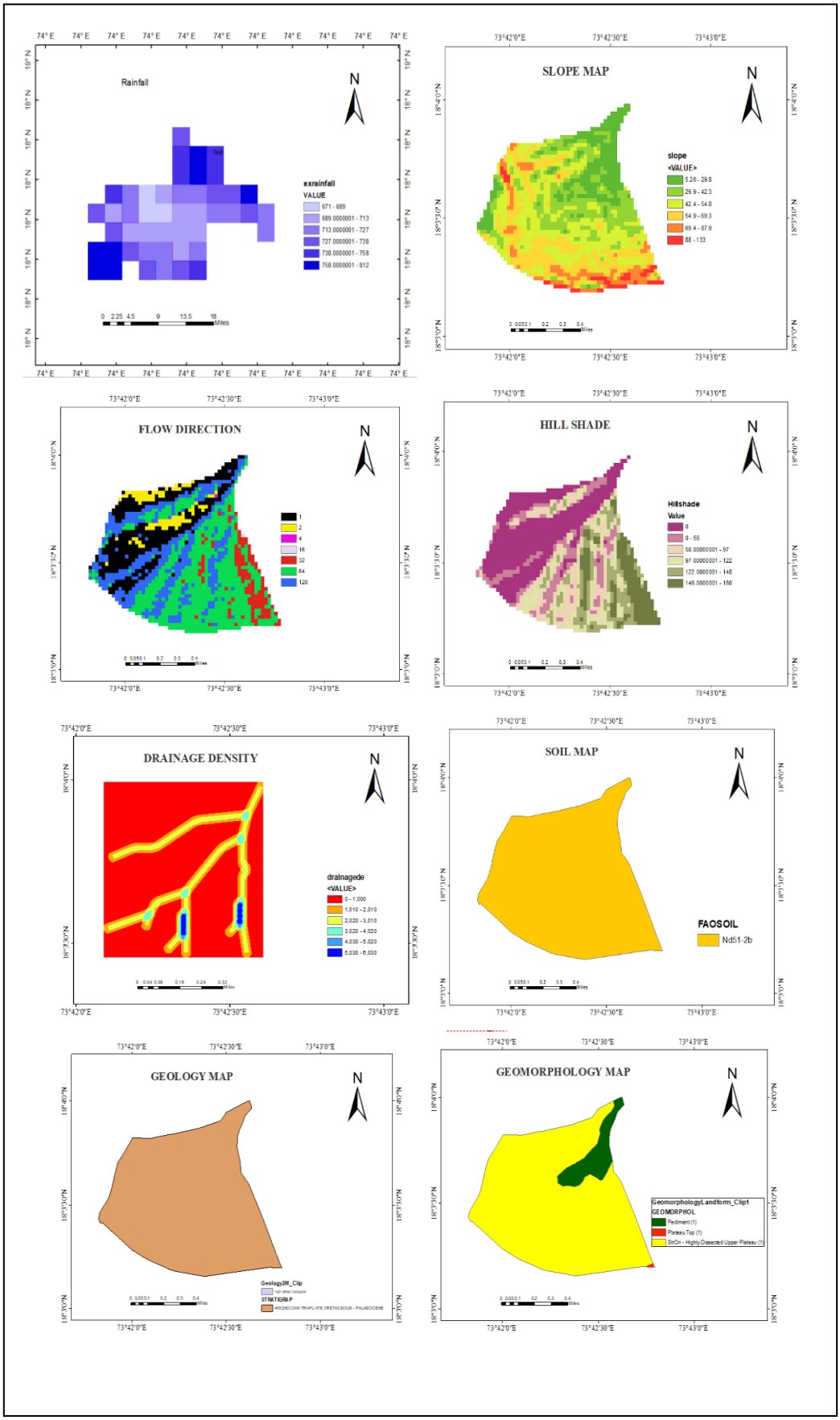

Fig :1.2 Thematic Maps of Various Parameters

B3.Analyatical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP), introduced by Thomas Saaty in 1980, is a method designed to

support decision-making, especially in complex scenarios. It involves evaluating various parameters and potential choices to identify the best decision. Weights are assigned to these parameters through the principal eigenvector of the pairwise comparison matrix, which reflects the relative importance of two variables. These weights are derived from pairwise comparisons using a continuous ranking scale in line with Saaty's methodology.

Table no.1:Saaty's reference

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, it dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6,8 can be used to express intermediate values		

AHP simplifies complex decisions by creating a hierarchy of decision elements (factors) and making pairwise comparisons between them to assign weights.

Essential Steps in AHP:

- **Decomposition:** Break down the decision problem into a hierarchy of more manageable sub-problems, each of which can be analyzed independently.
- **Pairwise Comparisons:** Evaluate the relative importance of each pair of elements within the same level of the hierarchy by comparing them in pairs and assigning a numerical value to express their relative importance.
- **PrioritySynthesis:** Calculate the weights (or priorities) for each element by normalizing the eigenvector associated with the largest eigenvalue of the pairwise comparison matrix.
- **Consistency Ratio**: Ensure the reliability of comparisons by calculating a consistency ratio (CR), with acceptable CR values generally being 0.1 or less.

Following these steps, AHP helps decision-makers articulate their preferences clearly, rank alternatives, and ultimately determine the best choice.

2. Methodology &Working

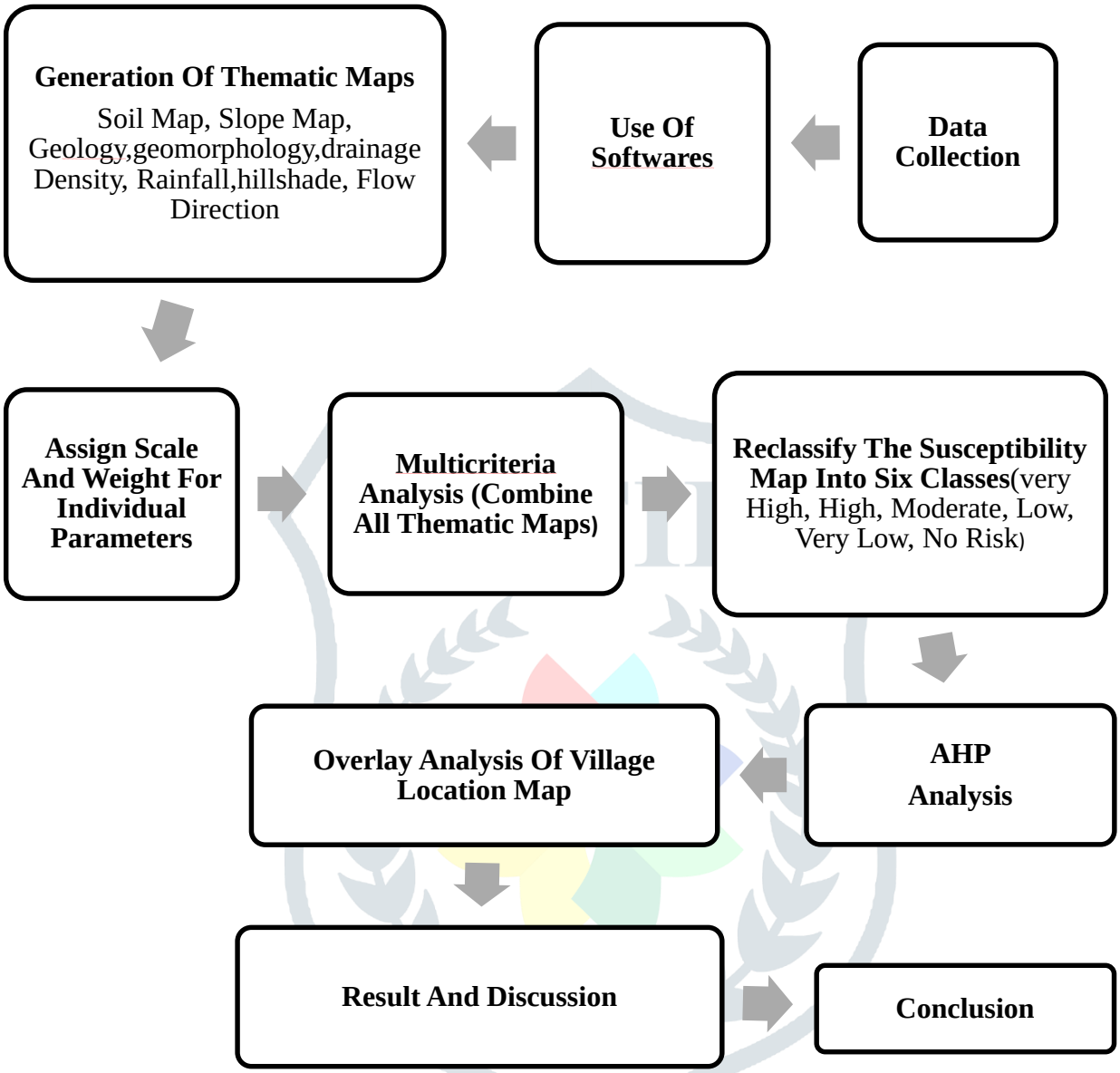

Fig 2.1:Methodology

3.RESULTS AND DISCUSSION

Calculated Consistency ratio which is 0.07 is less than 0.1

Table no.2: Weightage rating from AHP calculation

Criterion	Class	Reclass	Weights
Rainfall	671-689	1	32.70%
	689-713	2	
	713-727	3	
	727-738	4	
	738-758	5	
	758-812	6	
Geology	DECCAN TRAP	1	17.40%
Slope	5.25-29.8	1	
	29.9-42.3	2	
	42.4-54.8	3	
	54.9-69.3	4	
	69.4-87.9	5	
	88-133	6	
Drainage density	0-1000	1	9%
	1010-2010	2	
	2020-3010	3	
	3020-4020	4	
	4030-5020	5	
	5030-6030	6	
Hill Shade	0	0	7.30%
	0-58	1	
	58-97	2	
	97-122	3	
	122-148	4	
	148-190	5	
Flow Direction	1	1	7.30%
	2	2	
	4	3	
	18	4	
	32	5	
	64	6	
	128	7	
Soil Type	ND SOIL	1	4.90%
Geomorphology	PEDIMENT	1	5%
	PLATEAU TOP	2	
	strORI-Highly diss	3	

Eight Landslide Conditioning Factors- Slope , Drainage Density, Geology, Geomorphology, Flow Direction, Rainfall, Soil, And Hillshade -Were Used For Susceptibility Analysis In This Study's GIS-Based AHP Multicriteria Evaluation Approach To Identify Potential Landslide Occurrences In The Dhanivali Region. All of the factors' CR values were less than 0.10, indicating that the weights assigned were appropriate and trust worthy. Low, moderate, and high susceptibility occurrences account for 18%, 64%, and 18% of the entire research region, respectively, according to the analysis results displayed in Table.

This area is covered in ND type soil.(District nitrosols) Nitrosol soils, which are found in the research region and are often heavy in nitrogen, have certain characteristics that make them prone to landslides. Because of their great porosity and low cohesiveness, they are prone to erosion, especially after a period of intense rainfall or when human activity like construction causes them to become unstable. This erosion can

weaken the structure of the soil and increase the risk of landslides, especially on slopes.

The Deccan Traps, massive volcanic rockcan influence landslides due to their topography and composition. The steep slopes and loose, fractured rocks in the traps can make the area prone to landslides, especially during heavy rainfall or seismic activity. The volcanic activity that formed the traps also created weaknesses in the rock layers, making them more susceptible to erosion and slope failure.

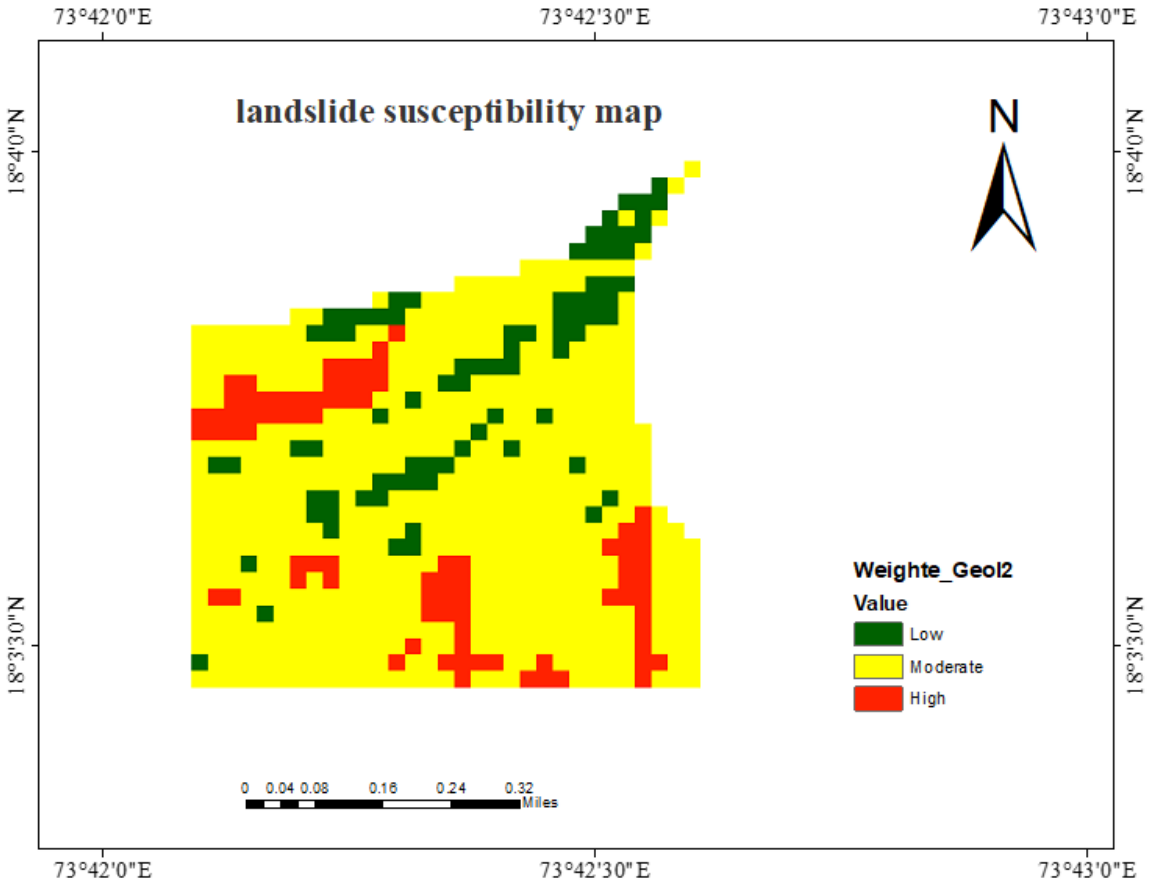

Fig 3.1:Landslide Susceptibility Map

4.CONCLUSION

1. The current study shows how Dhanavali Village, Maharashtra, is mapped for landslip vulnerability.
2. The Analytical Hierarchy Process is used to identify the zonation of landslip hazards, and the results indicate that around 18% of the study region's land area is susceptible to high to very high landslip hazards, with the potential for significant sliding in the side slope portions of mountainous regions.
3. whereas the land area covered by the Moderate and Low Hazard zones is approximately 64% and 18%, respectively.
4. Strongly advised for preventive and recommendations based on this outcome. It is possible to avoid these risks by taking the following preventative measures.

5.Preventive Measures

1. Since water serves as the primary trigger for mass movement, it is imperative to prevent its ingress into the affected area.
2. While the occurrence of landslides may be inevitable, their impact can be mitigated through timely preventive actions.
3. The scale of mass movement can be reduced by establishing an efficient drainage network.
4. Employing suitable engineering techniques, such as surface and subsurface drainage provision, removal of unstable slope materials, and stabilizing modifications to precarious slopes, along with constructing retaining walls around developed areas, can effectively minimize landslide occurrences.

5. Pore pressure significantly influences slope stability.
6. Soil erosion exacerbates landslide risks; mitigating this can be achieved by promoting vegetative growth in sloped areas.
7. Raising public awareness regarding agricultural practices alteration and controlling human-induced factors that can trigger landslides are crucial.
8. Many landslides are preceded by gradual creep movements over an extended period, providing a natural warning that can be utilized as a preventive measure.

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Received: Apr 26, 2010; Revised: Jul 13, 2010; Accepted: Aug 2, 2010