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Landslides Zones of Nearby Areas of Malin Village, Pune District, Maharashtra Using GIS Techniques

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Abstract: ***Landslides are predominant naturally occurring disasters in hilly terrains, often characterized by rugged hills with steep slope associated with loose unconsolidated soil. With its peak occurrence during the monsoon season, the magnitude of its effects can be disastrous depending on certain additional control factors- both natural and manmade. The present study encompasses the spatial analysis of the landslides prone areas nearby Malin Village using Satellite data along with the field data in a GIS Environment. Using GIS Technique, Thematic layers like lithology, geological structures, slope morphology, geomorphology and land use/land cover for deriving the landslides hazard zones. The weightage rating systems were used for different classes of thematic layers which are based on relative importance of various causative factors. The classes were assigned corresponding rating values as attribute information in the GIS environment. Each class within the thematic layer was assigned an ordinal rating from 1 to 10. The study indicates that the majority of the study area falls under moderate and low hazard zones, which further signifies that slope stability and manmade causes are still a major concern when taking up developing activities. In this context, the landslides hazard zonation map prepared in the present study will be useful for carrying out mitigation programmes as well as for planning and implementation of future developmental schemes within the study area.***

Keywords: Attributes, GIS, Landslides Zones, Thematic Maps, Weightage Overlay Analysis.

1. Introduction

A Landslide is a geological phenomenon that includes a wide range of ground movements. Landslides are usually classified on the basis of the material involved and the type of movement. They often take place in conjunction with earthquakes, floods, heavy rainfall and volcanoes. The landslide hazards cannot be completely prevented. Thus, Landslide Zones assessment is becoming an important task for the analysation of the resource use pattern, development of various thematic maps and for the disaster management planning. Landslides analysis is a complex analysis, while GIS is an easy and accurate method for analyzing and integrating various landslides triggering factors in a large volume.

2. Study Area

Malin is the village in the Ambegaon Taluka of the Pune district of Maharashtra State, India. It is located 85 kms towards the north from District Headquarter Pune, 25 kms from Ambegaon Gavthan and 103 kms from the State capital Mumbai. Pune District lies in the Ecologically Sensitive Zone I. The village is located in the ranges of Sahyadri Mountains having MSL 619 meters. Location map of the study area is shown in Fig 1. The study area is nearby areas of Malin village that lies between Latitude 73º40’ N to 73º45’ N and Longitude 19º10’ E to 19º5’ E . The topology of the area has been characterized by mountain, terraces and flood plains.

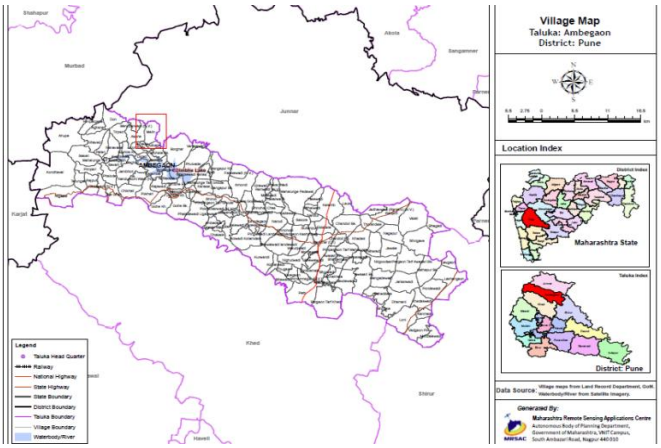

Figure 1: Location Map of the Study Area

3. Methodology and Materials

3.1 Methodology

Landslides maps are to be prepared by using thematic information on the existing landslides, vegetation status, drainage, slope and land forms generated using satellite data and Toposheet. The key analysis of the proposed analysis is GIS technology. GIS provides a powerful to context to import, manage and analyse spatially based data. The methodology is broadly classified into three steps, first the Input data which consist of preparation of thematic maps, second the Weighted Overlay Analysis and the final is the Landslide Zone Map which is divided into five zones. Detail methodology using GIS Technique is as follows

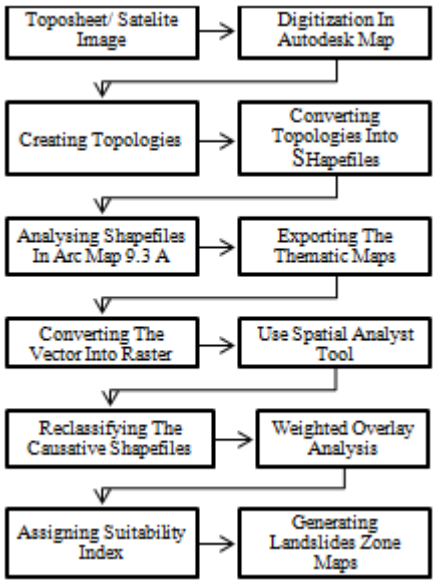

Figure 2: Methodology Adopted

3.2 Materials Used

Following materials were used inorder to develop a Landslides Zone map of the nearby areas of the Malin Village, Ambegaon Taluka, Pune District, Maharashtra State, India.

- Toposheet of the Survey of India 47 E 12 of year 1947 of Scale 1:50,000.
- Recent Satellite Image with resolution of 1 meter.
- Field Study of the Affected Malin Village.
- AutoDesk Map 2004 for Digitising the Features.
- Arc GIS 9.3 A for developing the features and developing Thematic Maps.
- Weighted Overlay Analysis.

4. Preparation of Thematic Maps

The following Thematic Maps were prepared for the study area.

- Landuse Map
- Elevation Map
- Slope Map
- Aspect Map
- Hill shade Map
- Flow Accumulation Map
- Major Streams Map
- Transportation Map
- Drainage Density Map
- Soil Map
- Soil Analysis
- Geology Map

4.1 Landuse Map

Vegetation cover is an important factor which influences the occurrence and movement of the rainfall which triggers the landslides. Light Vegetation is found as the major landuse in the watershed.

Table 1: Landcover Statistics of the Study area

Landuse Class	*Area (Sq.km)*	*Percentage*
Heavy Vegetation	11.233	13.797
Light Vegetation	20.606	25.309
Settlement	0.679	0.833
Cultivated Lad	19.363	23.782
Water Body	12.949	15.904
Scrubland	16.586	20.371
TOTAL	81.416	100

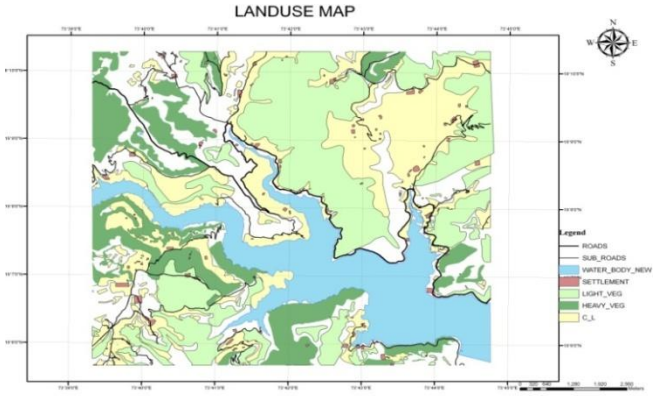

Figure 3: Landuse Map of the Study area

4.2 Elevation Map

The Elevation map is prepared from the Toposheet in order to know the exact elevation of the study area. The Elevation Map acts as Base Map to determine the Slope Map, Aspect Map and the Hill shade Map.

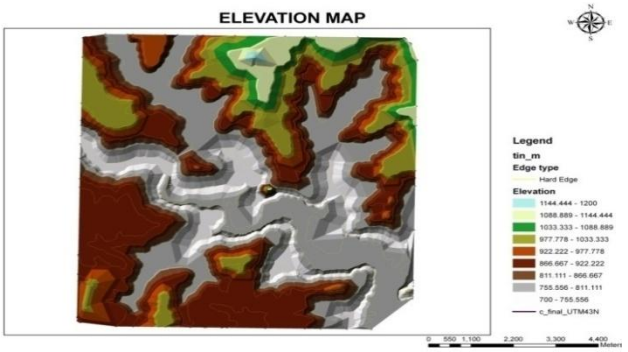

Figure 4: Elevation Map of the Study area

4.3 Slope Map

Slope is an important factor in the analysis of Landslides. As the slope increases the probability of the occurrence of landslides also increases. The slope map is derived from SOI Toposheet by GDEM method.

Table 2: Slope Statistics of the Study area

Degree of Slope	*Area (sq.km)*	*Percentage*
0-8	37.5	46.05
8-17	13.75	16.88
17-26	17.45	21.43
26-35	7.53	9.24
35-43	3.37	4.17
43-86	1.8156	2.23
Total	81.4156	100

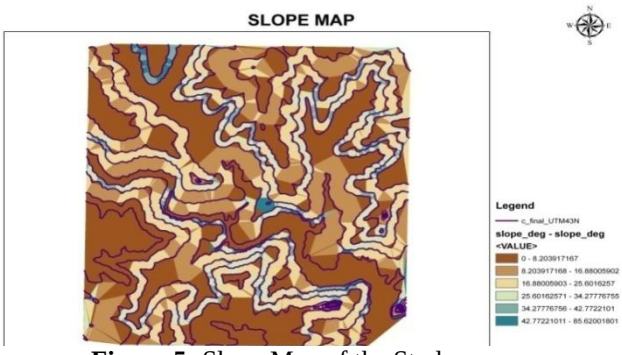

Figure 5: Slope Map of the Study area

4.4 Aspect Map

Aspect is the Compass direction that faces the slope. Aspect has a great influence on vegetation. Parameter of aspect such as exposure to sunlight, drying winds, rainfall and discontinuities may control the occurrence of landslides.

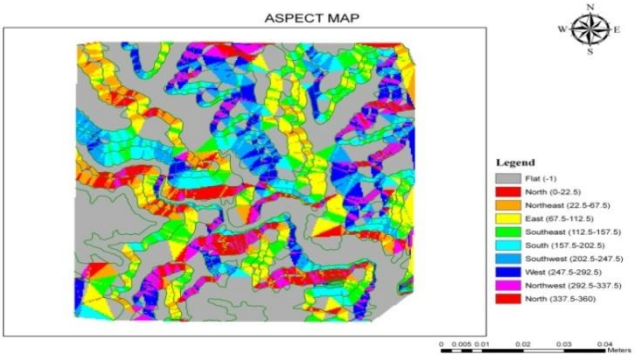

Figure 6: Aspect Map of the Study area

4.5 Hill Shade Map

Hill shade is the technique used to create realistic view of terrain by creating 3 Dimensional surfaces from 2 Dimensional. Hill shade creates a hypothetical illuminating surface .The light source is placed in the northwest direction.

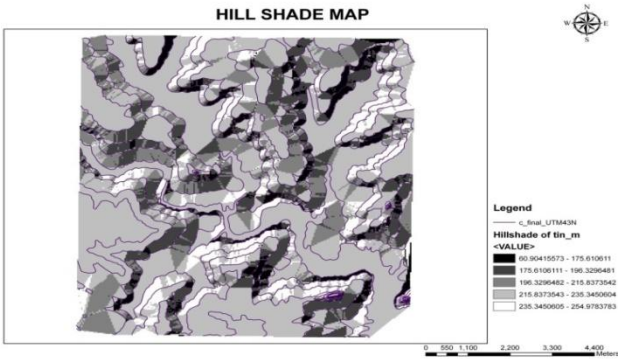

Figure 7: Hill Shade Map of the Study area

4.6 Flow Accumulation

The Hydrological modelling functions in ARC GIS Spatial Analyst Tool is used to determine the flow direction, indentify sinks and to calculate the Flow Accumulation and to create stream networks.

Table 3: Flow Accumulation Statistics of the Study Area

Values (m/m^2)	*Classification*
20-12	Very High
12-8	High
8-4	Moderate
4-1	Low
0-1	Very Low

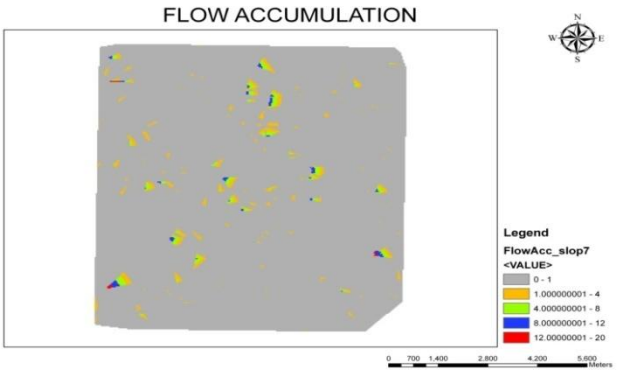

Figure 8: Flow Accumulation Map of the Study area

4.7 Major Streams Map

The Major Stream Network map are further classified into five zones ranging from very high to very low and the same are used to derive 100 meter buffer for each classes.

Table 4: Major Streams Statistics of the Study Area

Stream Order	*Length (meters)*
1st Order	1.414
2nd Order	0.332
3rd Order	0.129
4th Order	0.100
5th Order	0.010
River	0.087

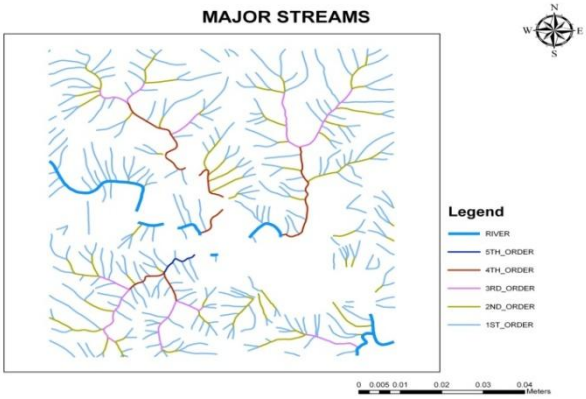

Figure 9: Major Streams Map of the Study area

4.8 Transportation Map

Transportation Map is been prepared from Satellite Image by digitizing features such as main roads and Sub-roads. Transportation density is derived from Transport Map

Table 5: Transportation Statistics of the Study Area

Transportation Class	*Length (meters)*	*Buffer (meter)*
Roads	26332.5	100
Sub roads	69111	50

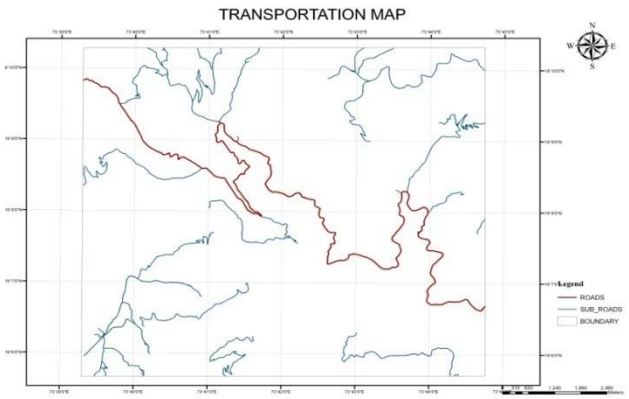

Figure 10: Transportation Map of the Study area

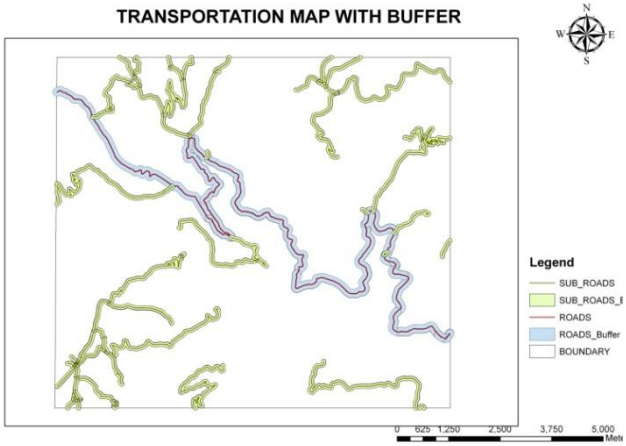

Figure 11: Transportation Map with Buffer of the Study area

4.9 Drainage Density

Drainage map shows the flow of water throughout the study area. As the distance from the drainage line increases the probability of occurrence of landslide also increase. Majority of the watershed falls under high density area as the stability of the slope is disturbed by terracing.

Table 6: Drainage Density Statistics of the Study Area

Stream Order	*Drainage Density (m/m^2)*	*Classification*
1st Order	0.00173	Very High
2nd Order	0.000407	High
3rd Order	0.000158	Moderate
4th Order	0.000122	
River	0.000106	
5th Order	0.0000122	Low

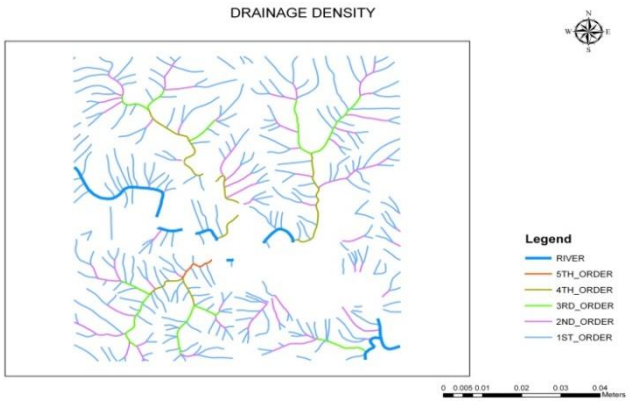

Figure 12: Drainage Density Map of the Study area

4.10 Soil Map

Soil Map is a geographical representation showing diversity of soil types and properties. This area is covered by 2 types of soil namely the Black Cotton Soil and the Calcareous and Clayey Soil.

Table 7: Soil Statistics of the Study Area

Soil Class	*Area (sq.km)*	*Percentage*
Black Cotton Soil	19.3630	23.78
Calcareous and Clayey Soil	62.0526	76.22
Total	81.4156	100

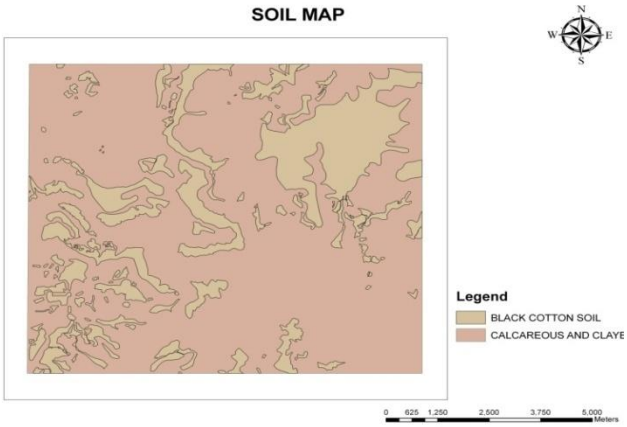

Figure 13: Soil Map of the Study area

4.11 Soil Analysis

From the field study, 6 samples from the landslide affected area is collected and analysed to determine the nature of the soil.

Table 8: Soil Analysis Statistics of the Study Area

Soil Sample	*pH*	*Electric Conductivity*	*Nature of Soil*
1	7.31	0.616	Neutral
2	6.38	0.698	
3	7.14	0.588	
4	7.43	0.612	
5	6.74	0.419	
6	7.20	0.611	

3.12 Geology Map

The geology map is prepared from the geological survey of India mineral map. Structurally the area is highly disturbed and subjected to faulting. The watershed is entirely covered by Basalt rock.

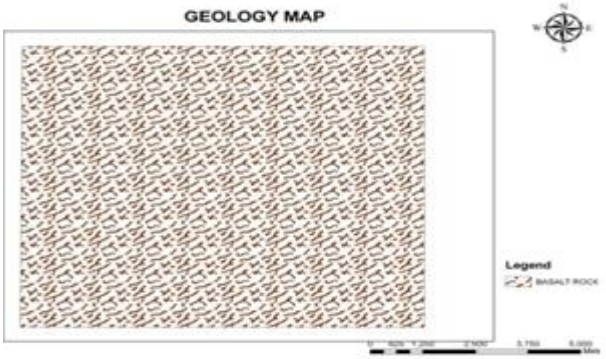

Figure 14: Geology Map of the Study area

5. Results and Discussion

5.1 Weightage Rating Systems

Weighted rating system is based on the relative importance of various causative factors derived from field knowledge.

Table 9: Weightage Rating Statistics of the Study Area

Sr No	*Factors*	*Weightage*	*Causes*	*Attribute*
1	Landuse /Landcover	9	Light Vegetation	20
		8	Cultivated Land	
		7	Scrubland	
		6	Water Bodies	
		5	Heavy Vegetation	
		4	Settlements	
2	Slope	8	86 – 43	20
		7	43 – 35	
		6	35 – 26	
		5	26 – 17	
		4	17 – 8	
		3	8 - 0	
3	Aspect	8	South	10
		7	South East	
		6	South West	
		5	West	
		4	East	
		3	North	
		2	North East	
		1	North West	
4	Hill Shade	7	High	10
		5	Moderate	
		3	Low	
5	Main Stream	8	1st order	5
		7	2nd order	
		6	3rd order	
		5	4th order	
		4	5th order	
		3	River	
6	Soil	8	Black Cotton Soil	10
		6	Clayey & Consolidated soil	
7	Geology	8	Basalt rock	10
8	Transportation	8	Roads	5
		6	Sub-roads	
9	Drainage Density	8	0.00173	10
		7	0.000407	
		6	0.000158	
		5	0.000122	
		4	0.0000122	
		3	0.000106	
10	Flow Accumulation	8	Very High	10
		7	High	
		6	Moderate	
		5	Low	
		4	Very Low	

5.2 Weighted Overlay Analysis

The Vector data processed in the Input Map is then converted to Raster Data and then taken as input data to Spatial Analyst Tool and Weighted Overlay Analysis is performed. The results of the Weighted Overlay Analysis results are in the form of pixels. The pixels data are further analysed using polygon features to form the Landslides Zones Map.

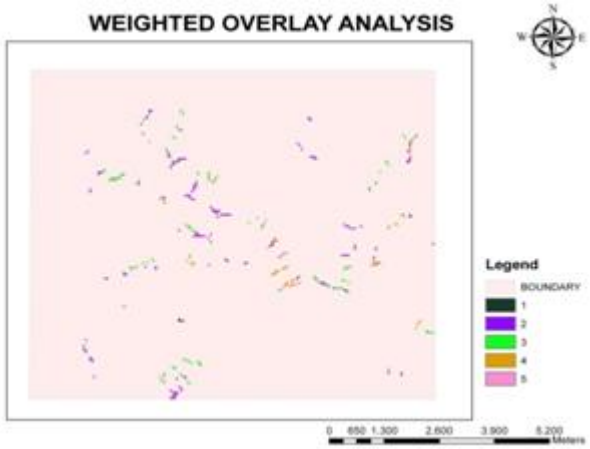

Figure 15: Weighted Overlay Analysis Map of the Study area

5.3 Landslides Zones Mapping

The last step of the Methodology is Landslides Zone Mapping of the study area. The pixel data derived from the above Weighted Overlay Analysis are digitized to form polygons and the study area is divided into five different zones ranging from very low to very high.

Table 10: Landslides Zone Statistics of the Study Area

Sr No	*Classification*	*Area (Sq.km)*	*Percentage*
1	Very High	1.4616	1.79
2	High	9.7241	11.94
3	Moderate	5.8874	7.26
4	Low	4.9135	6.03
5	Very Low	1.4001	1.71
6	No Hazard	58.0289	71.27
TOTAL		81.4156	100

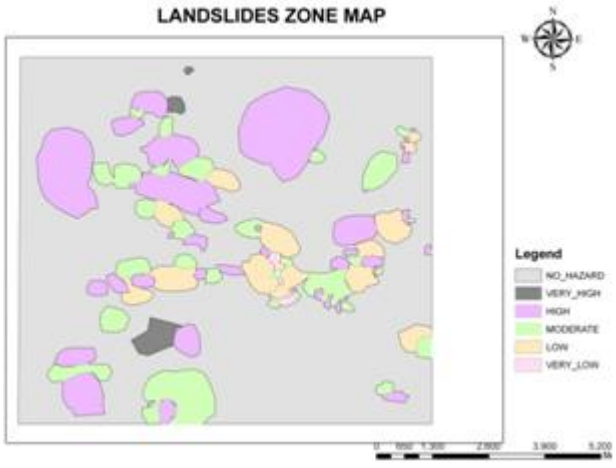

Figure 16: Landslides Zone Map of the Study area

Based on the landslides zones map following observations are made:

- Steep slope is found on the South Eastern region, very steep slope is found in the middle of the study area near Dam.
- Light vegetation is found as the major Landuse in the watershed.
- Majority of the water shed falls under the High Drainage density category.
- The entire watershed area is covered by Basalt Rock.

- Dense forest falls under the western region of the watershed is found to be Moderate Hazard.
- Deforestation and soil erosion is highly observed in the sloping area.

6. Conclusion

Unstable slopes are really the challenge in the study area. The Landslides caused usually in Rainy season's causes the loss of property and life. The present study has proven that the advent of GIS techniques with the wide availability of satellite images have greatly facilitated in the identification of landslides hazard zonation. From the above study it is clearly observed that though landslide is a naturally occurring disaster, the landslide happened in Malin village was triggered due to many human caused factors with the close association of heavy rainfall. The main factor responsible for the landslides in Malin village is due to the Padkai scheme of Government which basically is providing plots to the resident for farming purposes with terracing the hill slopes.

7. Preventive Measures

- As the principal of the initiation of mass movement is water, this main causative agent has to be prevented from entering into the affected area.
- The occurrence of the landslides cannot be prevented but its affects can be minimized by taking timely preventive measures.
- The magnitude of the mass movement can be minimized by construction an efficient drainage network
- Landslides can also be minimized by using appropriate engineering technology which involves provision of surface as well as subsurface drainage, removal of unstable slope material and modification of unstable slope to stability, lastly construction of retaining walls in the periphery of the area where Padkai is developed.
- The pore pressure plays an important role in the stability of the slope,
- Soil Erosion is also the causative factor; this can be reduced by increasing the vegetative growth in the sloping areas.
- Public awareness about changing the agricultural practices as well as controlling the human made parameters that can initiate to landslides.
- Most of the landslides are preceded by creep movements over a long period of time, this natural warning can be used to ensure as a preventive control measure.

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