

# Geo Environmental Analysis of Landslide and Modelling for Locating Slide Prone Areas of Palakkad District, Kerala,India

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**Abstract** - A landslide means a natural phenomenon in which a large kind of ground movement processes, like rock falls or debris flows. Landslides, also called as landslips, slope failures or slumps are the most common Geo-hazards occurring in areas like mountainous regions. Landslide is caused by natural factors or by human activities. Which leads to environmental degradation, damage to buildings, roads, railways, pipelines, agriculture lands and communication networks. Landslide susceptibility means the likelihood of a landslide occurring in a region, or which shows where landslides are chance to occur. The study area, Palakkad district is vulnerable to landslides, and are hit by landslides during the past few years. GIS techniques and Frequency Ratio Model was used in this study to assess the contribution of conditioning factors to landslides, and to create a landslide susceptibility map of the study area. within the present study, the following influencing factors are selected slope, elevation, aspect, soil, lithology, drainage density, rainfall, land use/land cover, road density, geology and geomorphology. The landslide susceptible map is prepared and that divides study areas into five zones that is very high risk zone, high risk zone, moderate risk zone, low risk zone and very low risk zone. The results of study help to understand landslide risk zones of Palakkad district and also the landslide susceptible zone map is of great benefit for the geoscientists, engineers and experts in planning and development.

**Key Words:** Landslide, Geo-hazard, Geographic information system(GIS), Frequency ratio model, Kerala, Palakkad district, Susceptibility.

## 1. INTRODUCTION

A landslide is a natural phenomenon in which a large kind of ground movement processes, like rock falls or debris flows under the influence of gravity. Landslides became a serious threat within the recent times because of the intervention of people and causes severe damage to life and property. Human activities like deforestation, land-filling mining, unscientific developmental activities etc are the causative factors to landslides. Landslides cause destruction to property, injury and death to animals and humans. Landslides damages communication lines,

railway lines, dams, water supplies, road networks, bridges, etc.. Landslides also leads to economical degradation and have socioeconomic impacts on people. Kerala is prone to landslides and receive high amount of rain every year. Objectives of this study are to Identify landslide Susceptible regions of Palakkad district, to Prepare landslide susceptible map for the study area using Geographic information system(GIS), to find and analysis the factors that causes landslide in the area and to analysis terrain parameters related to landslides. In this study 13 parameters slope, aspect, elevation, drainage, stream network, road, Land use, lineament, soil type, rainfall geology, geomorphology and lithology are used.

### 1.1 Study Area

The study was conducted at Palakkad district, Kerala. The latitude of Palakkad district is 10.784703, and also the longitude is 76.653145. The study area is found with the GPS coordinates of 10° 47' 4.9308" N and 76° 39' 11.3220" E. The total area of the district is 4,480 km<sup>2</sup>. 1,360 km<sup>2</sup> of land is covered by forests out of total area.

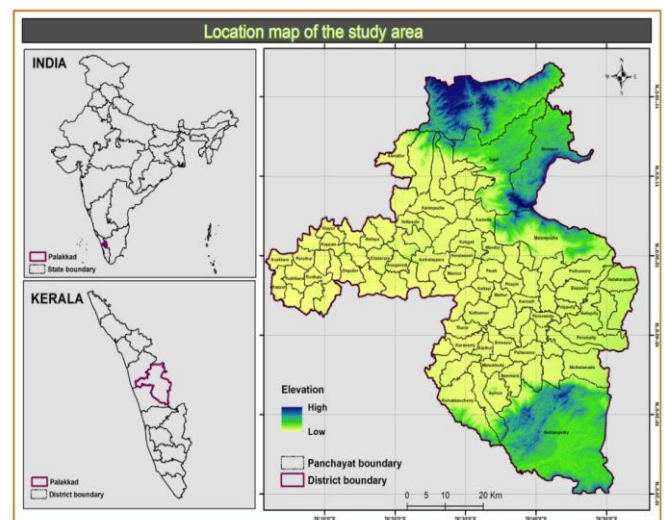


Figure -1: Study Area-Palakkad district

## 2. MATERIALS AND METHODS

Geological Survey Of India prepared the drainage map which was vectorized from the Topographical map. Road network map and stream network map prepared from Open series Map (OSM). ASTER GDEM downloaded from 'Global Data Explorer' of US Geological Survey was processed to derivate the slope, aspect, and elevation data.

The Geology map was prepared from the Geological Quadrangle map, prepared by Geological Survey of India in 1: 50,000 scale. Geomorphology map and Lithology map prepared using geological data and GIS. Data related to land use land cover and lineaments were obtained from 'Bhuvan' web map service.

Soil map prepared using data from Department of Soil Survey and Soil Conservation, Thiruvananthapuram, is used for creating the soil map of the study area. Rainfall map prepared using the data obtained from Indian Meteorological Department (IMD).

The Landslide Susceptibility(or vulnerability) Zonation map divided the land surface into zones that have likelihood for landslide occurrence. susceptibility values represent the net probability of occurrence of landslide at that particular point. Frequency Ratio Model is used to prepare maps. The frequency ratio is the ratio of landslide occurred to the total area, so that the value of 1 is the average value. If the the value is >1 or Probability is higher, then there is a greater susceptibility for landslides. The lower degree of landslide susceptibility in the region is represented by lower value(< 1).

The formula is as follows:

$$Fr = (Mi/M) / (Ni/N)$$

Where

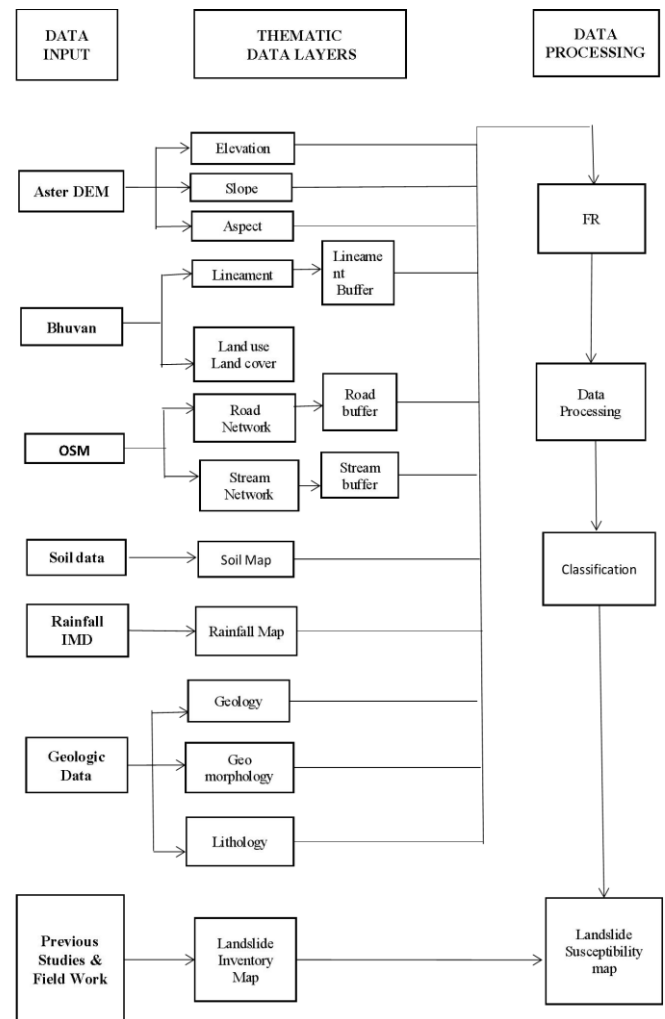
Mi= number of pixels with landslides for each conditioning factor subclasses,

M = total number of landslides in the study area,

Ni= number of pixels in the subclass area of each factor and

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

### Flow Chart of Materials and Methods



## 3. RESULTS AND DISCUSSION

### 3.1 Land Use Land Cover

Land cover mapping, a method that quantifies present land resources into a variety of thematic categories such as forest, grass, agriculture, waste land, wet land water and build ups makes it simple to measure present circumstances. The land cover map is given below. The higher chance of landslide occur in evergreen/semi evergreen Forest. The frequency ratio is 1.93.Landslides also mostly occurs in agriculture plantations, forest plantations and scrub forest.

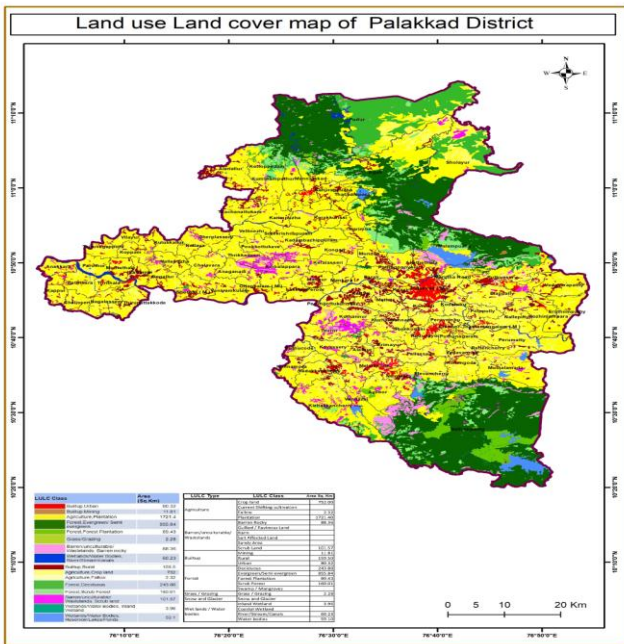


Figure -2: Land use land cover map of palakkad

### 3.2 SLOPE

Slope is one of the major factors affecting landslide. It is expressed as percentage or degree. The chances of landslide occurrence also increases with increasing slope value. The slope angle values were divided into nine categories:  $0^{\circ}$ - $5^{\circ}$ ,  $5^{\circ}$ - $10^{\circ}$ ,  $10^{\circ}$ - $20^{\circ}$ ,  $0^{\circ}$ - $20^{\circ}$ ,  $30^{\circ}$ - $40^{\circ}$ ,  $40^{\circ}$ - $50^{\circ}$ ,  $50^{\circ}$ - $60^{\circ}$ ,  $60^{\circ}$ - $70^{\circ}$ ,  $70^{\circ}$ - $77.75^{\circ}$ . The highest number of landslide occurs in 20-30 classes and frequency ratio is 3.23.

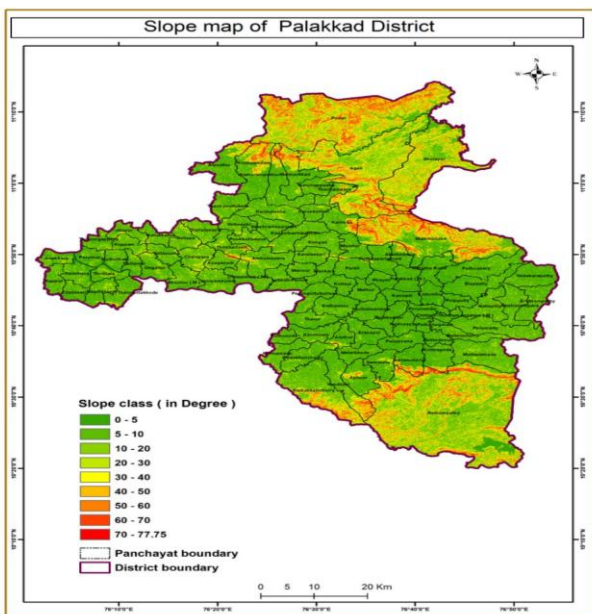


Figure -3: Slope map of Palakkad district

### 3.3 ELEVATION

Elevation is another natural factor. In the areas of higher elevation, the possibility of landslide occurrence is comparatively more than that of lower elevation. In areas of lower elevation terrain is mostly gentle and a higher water table is required to initiate slope failure. Here the study area is split into 9 classes viz.  $< 25$ ,  $25 - 50$ ,  $50 - 100$ ,  $100 - 200$ ,  $200 - 500$ ,  $500 - 1000$ ,  $1000 - 1500$ ,  $1500 - 2000$ ,  $> 2000$ . Highest number of landslide locations is found in 500 - 1000. The frequency ratio is 2.33. The chance of occurrence of landslide is more in the following classes 500-1000, 200-500 and 1000-1500.

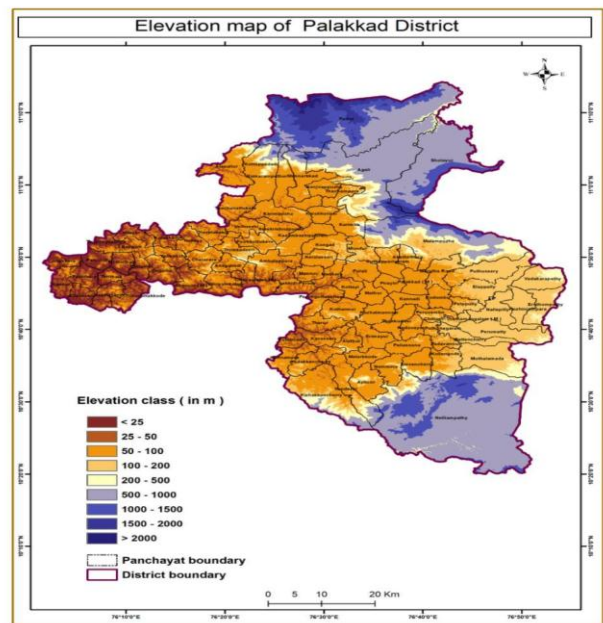


Figure -4: Elevation map of Palakkad district

### 3.4 ASPECT

Aspect is the direction of slope. The most landslide areas are in North, North East, East and South East, South, South West, West, and North West. Highest number of landslide locations is found in West. The frequency ratio is 1.55. The chance of landslide is more in these areas West, South East, South and East.

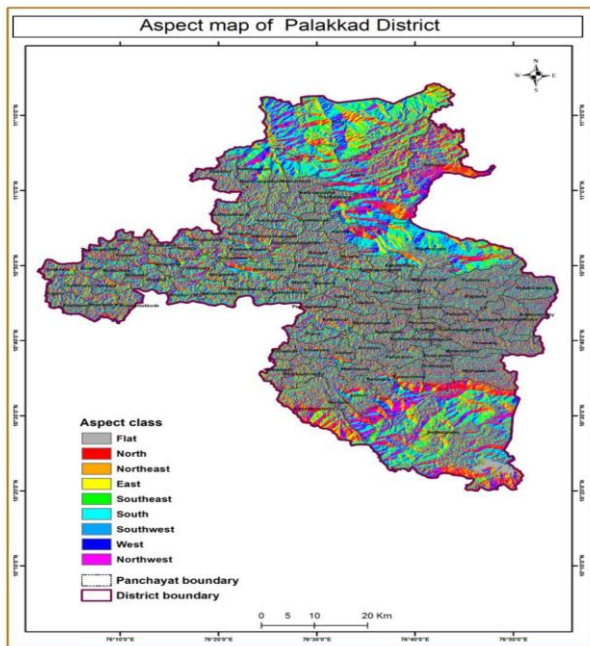


Figure -5:Aspect map of Palakkad district

### 3.5 ROAD NETWORK

Another factor that effect landslide is distance from road. Here the study area is divided in to 5 classes < 100,100 m - 200 m, 200 m - 300 m,300 m - 400 m,400 m - 500 m. The higher chance of landslide occurs in the road buffer class of < 100 . The frequency ratio is 2.88. The lowest chance of landslide occurs in the road buffer class of 200 m - 300 m. The frequency ratio is 0.14.

### 3.6 DRAINAGE

Drainage density is a factor which shows perviousness of strata, vegetation, rainfall and stream flow. High drainage density indicate impervious strata, high rainfall, less vegetation and active stream flow. There are five classes of which < 100, 100 m - 200 m, 200 m - 300 m has the highest number of landslide areas. It has frequency showing 1.24,1.16,0.64. Higher the density lesser will be the chance of landslide.

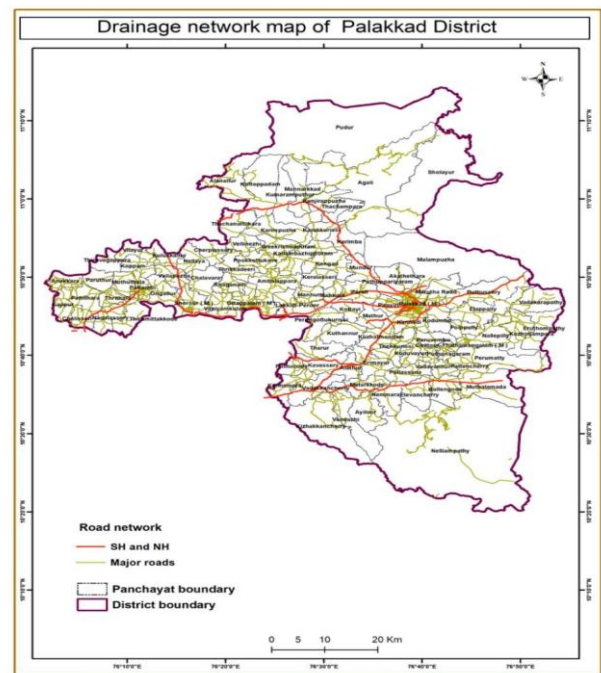


Figure -7:Drainage map of Palakkad district

### 3.7 LINEAMENT

Geological structural features like the discontinuities that may be detected as lineaments using satellite imagery, it is also related to landslide occurrences. Lineament shows the region of weakness where the strength of the slope material is week , it leads to slope failure. There are five classes of which 400 m - 500 m,300 m - 400 m, 200 m - 300 m has the highest number of landslide areas. It has frequency showing 1.54, 1.01 and 0.89. Higher the lineament buffer higher will be the chance of landslide.

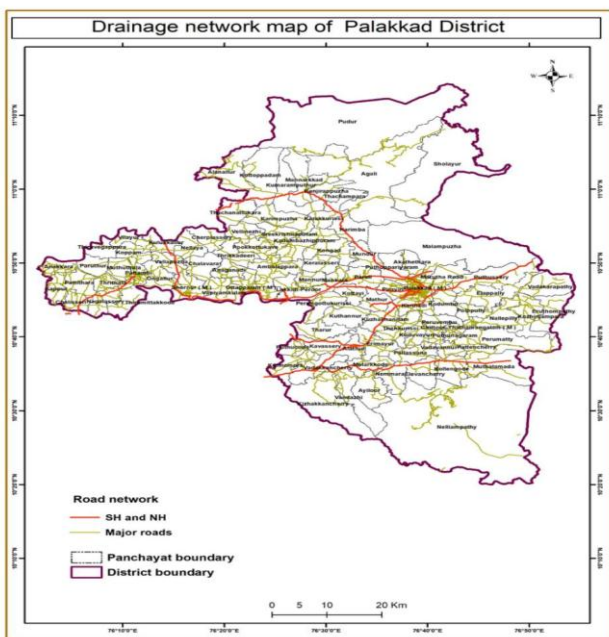


Figure -6:Road network map of Palakkad district

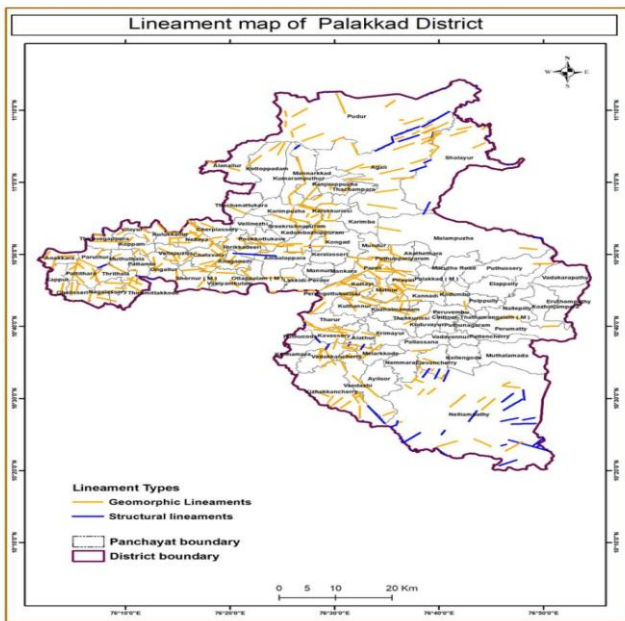


Figure -8:Lineament map of Palakkad district

### 3.8 SOIL TYPE

The properties of the soil also affect the landslide occurrence. There are four classes of which Dystric Nitosols, Lithosols and Humic Acrisols has the highest number of landslide areas. It has frequency showing 1.29,3.72,1.87.

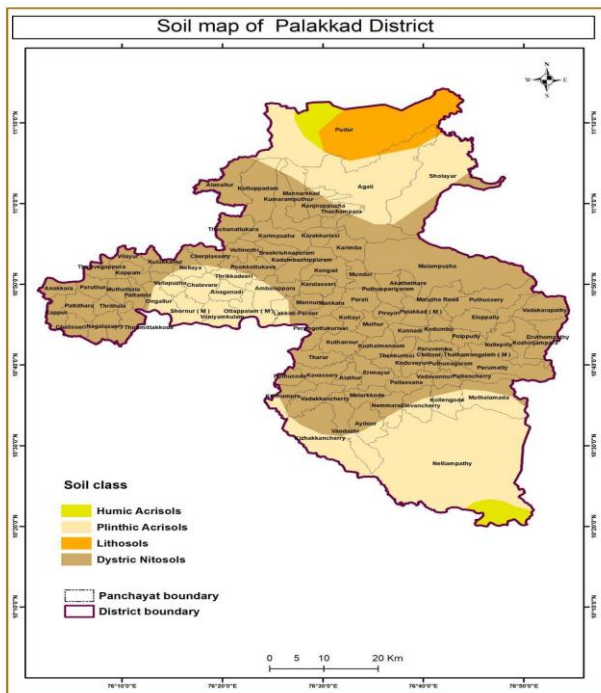


Figure -9:Soil map of Palakkad district

### 3.9 RAINFALL

Rainfall is most important cause of Landslides. There are five classes of which 1500-2000, 2000-2500, 2500-3000 has the highest number of landslide areas. It has frequency showing 1.18, 1.06, 0.58. Area which receive heavy rainfall is more prone landslide.

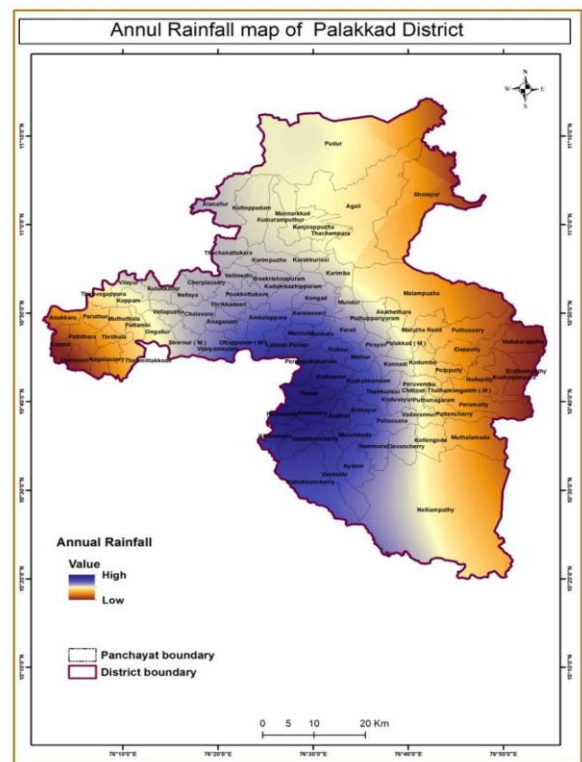


Figure -10:Rainfall map of Palakkad district

### 3.10 GEOLOGY

Areas which are weak, poorly consolidated and incompetent type of rocks are more risk to landslide. Presence of hard, strong and stable rocks shows stability to the slope, and make less risk to landslide. There are six classes of which MIGMATITE GNEISSIC COMPLEX (SOUTHERN GRANULITE TERRAIN), CHARNOCKITE GNEISSIC COMPLEX (SOUTHERN GRANULITE TERRAIN), PENINSULAR GNEISSIC COMPLEX-I has the highest number of landslide areas. It has frequency showing 0.98,0.89,2.31.

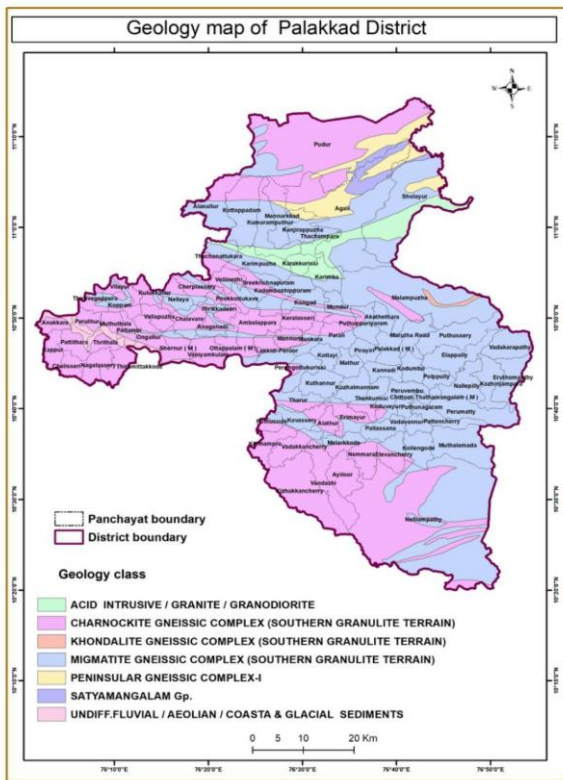


Figure -11:Geology map of Palakkad district

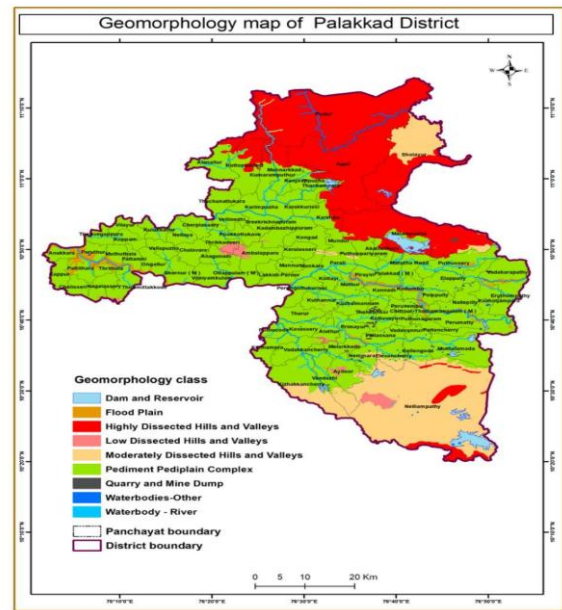


Figure-12:Geomorphology map of Palakkad district

### 3.11 GEOMORPHOLOGY

Geomorphology is the study of surface features of earth crust like land forms, origin and development of land-forms and mechanism of geomorphological processes which evolve the land forms. There are nine classes of which Highly Dissected Hills and Valleys, Moderately Dissected Hills and Valleys, Pediment Pediplain Complex has the highest number of landslide areas. It has frequency showing of 2.82319412 , 2.125381507, 0.116131536.

### 3.12 LITHOLOGY

Landslides can occur in different lithologies. There are Twenty nine classes of which acid to intermediate charnockite, Hornblende- Biotite, Garnet Gneiss has the highest number of landslide areas. It has frequency showing of 0.93, 0.46, and 2.85.

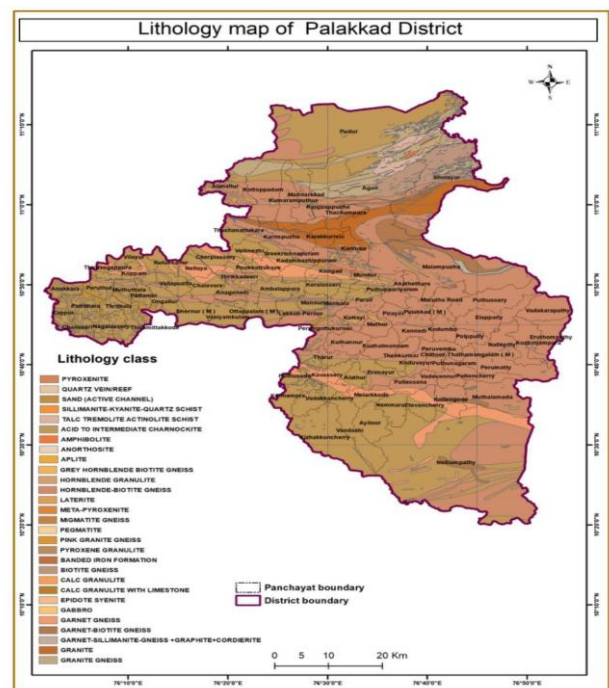


Figure-13:Lithology map of Palakkad district

### 3.13 LANDSLIDE HAZARD ZONATION MAPPING

Landslide risk zone map is created by combining the other maps using GIS tools. It is then classified in to five classes: very low, low, moderate, high and very high. 4,480 km<sup>2</sup> is the total area of Palakkad district out of which 29.49 km<sup>2</sup> area falls under the very high risk zone. 58.01 km<sup>2</sup> area falls under high risk zone, 191.24 km<sup>2</sup> area falls under moderate zone and 562.46 km<sup>2</sup> falls under low risk zone and 3640 km<sup>2</sup> area in very low zone.

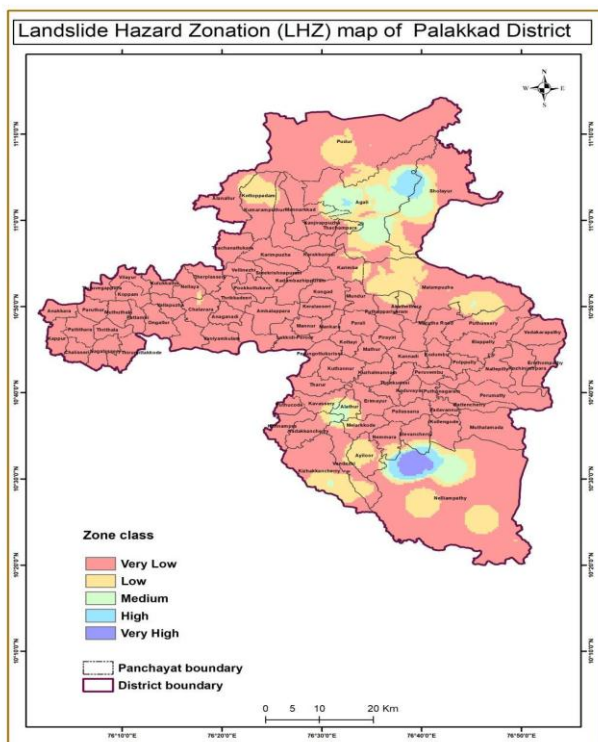


Figure-14:Landslide Hazard Zonation map of Palakkad district

### 4. CONCLUSION

Landslide has become one of the common natural hazards in the world. Most of the landslide are caused due to human activities. There are many factors that control the landslides. Aspect, slope, elevation, land cover type, geology, distance from road etc. In order to know how the landslide can affect we need proper management.

In this study, Palakkad is selected to know the landslide risk zones of the area. In order to study the area GIS tools have been used. Using GIS, maps of the study area were created by choosing the factors that affect the landslide. All these maps were then superimposed to form the landslide risk zone map of the area. The map is then divided in to five zones: very low risk zone, low risk zone, moderate risk zone, high risk zone and very high risk zone. By this we get about 29.49 km<sup>2</sup> area has been

reported as landslide very high risk zone. 58.01 km<sup>2</sup> area falls under high risk zone, 191.24 km<sup>2</sup> area falls under moderate zone and 562.46 km<sup>2</sup> area falls under low risk zone and 3640.8 km<sup>2</sup> area in very low zone.

Most of the landslides have been due to the human interaction. Deforestation, Heavy Rainfall and Earthquakes, Mining, Urbanisation etc causes landslide. So we need a proper management for this natural hazard. There are also different methods of preventing landslide. These include slope geometry modification, for reinforcing slope material using chemical materials, use of piles and retaining walls, rerouting surface and underwater drainage and diverting debris pathways. The study has been successful in showing the landslide risk zone of the Palakkad district. Hazard zonation mapping using GIS and remote sensing techniques gives latest and accurate information regarding the landslide.

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