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Mapping of topographical features of landslide affected areas of Kodagu using GIS software

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Abstract
Kodagu is one of the most beautiful district of Karnataka. Kodagu is located on the eastern slopes of the Western Ghats which is well known in the world for coffee and its “brave warriors”. Though it is the most beautiful city in India also it is facing the some of the hazards impacts such as floods, heavy rainfall and landslides. In this present study the topographical features which are responsible factors for the landslides are extracted such as slope, aspect, elevation, contours and drainage and they were investigated in the landslide affected areas. The new approaches of using GIS software for the extraction of these features were studied. The standard methodology of extracting topographic features such as contours, slope and drainage lines of the study area was done using DEM - Arc hydro tool software. As a result, the most of the landslide occurred in the elevation of from 627-1126m and slope at 60% showed the highest landslide area. Major factor drainage map showed that many of the smaller first order streams have dried up reducing the drainage density per unit area and blockage of natural drainage channels, changing the course of flow direction was observed. There is the need of re enabling the natural drainages and steep slope (>30%) need to be stabilized by bench terracing. There are needs to promote cultivation of deep-rooted indigenous plants in affected and vulnerable areas.

Keywords: Western Ghats, topographical features, GIS software, DEM, arc hydro tool

1. Introduction

The most beautiful hill station in Karnataka is Kodagu (Coorg), a heavily forested majesty on the Western Ghats. It is the least populated of the 30 districts of Karnataka, with a population of 548,561 as of 2001, 13.74% of who lived in the district's urban centres. It is located in the Western Ghats in southwest Karnataka and spans an area of 4,102 square kilometres (1,584 sq mi). According to the 2011 census, the district has a total area of 4102 km^2 and a population of 5,54,762. With an average annual rainfall of 4000 mm, the height varies from 900 to 1750 metres above mean sea level. The typical temperature is between 20 and 24 °C. The organization's headquarters are in the hill town of Madikeri, 252 kilometres from Bengaluru, the capital of Karnataka. The district is split into two forest divisions, Madikeri and Virajpet, each of which has a national park and three wildlife sanctuaries (WLS-Bramhagiri, Talacauvery, and Pushpagiri) (NP-Nagarahole). Numerous additional species, including the Critically Endangered *Syzgium travancoricum* and the Vulnerable *Gymnacranthera canarica*, are found in the region's Myristica swamps.

The Kodagu district experienced numerous landslides in 2018, which significantly damaged both lives and property. In and around the landslide damaged regions, topsoil loss, slope collapse, and sedimentation of low-lying areas were noted. The size of the area eroded by the impact of a landslide may grow with the action of rain each year. In addition to reducing the amount of fertile soil, erosion causes the loss of organic matter and plant nutrients, silts up reservoirs and riverbeds, which negatively affects irrigation and power potential, and causes floods in plains and valleys that harm crops, animals, habitation, communication, and other factors (Mishra *et al*., 2010) [6].

In addition to disrupting the ecological balance, it has a negative impact on agricultural productivity, forest cover, and the availability of water for drinking and irrigation. In our nation, soil erosion results in the loss of 5330 million tonnes of top soil and 5-8 million tonnes of nutrients per year.

It takes nature almost ten thousand years to develop a 2.5cm of thick layer of fertile soil. If these soil losses are avoided, it is predicted that agricultural production will increase by 30-40% (Ram *et al*., 2011) [9].

Therefore, the present study is taken to assess the which are the topographical features are responsible for the landslide using GIS software's and tools for the extraction of these topographical features.

2. Materials and Methods

2.1 Study area

Kodagu district, which is located in the central part of Western Ghats, is one among the eight hottest hotspots of biodiversity situated mainly on the Western slopes. Kodagu features a tropical highland climate, lies in the latitudes 11°55′00″ to 12°50′00″ N and longitudes 75°22′00″ to 76°11′00″ E (Fig 1) and the altitude ranges from 800-1700 m above MSL. Mean annual temperature is 24 °C and it ranges from 25 °C to 31 °C during hot months (Pascal and Maher, 1986). Nestled amid evergreen hills that line the southernmost edge of Karnataka is the luscious Kodagu (Coorg) region, gifted with emerald landscapes and hectares of plantations.

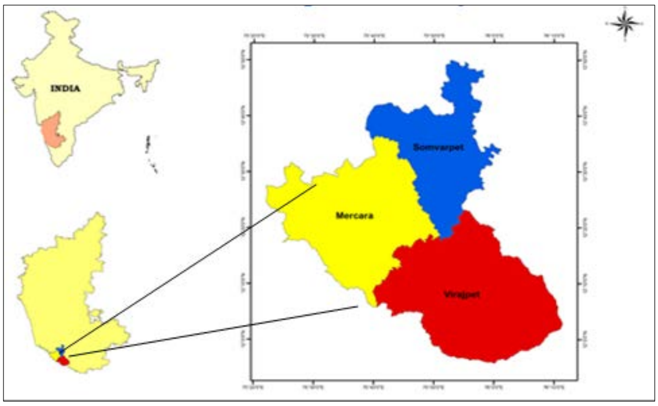


Fig 1: Geographical map of the study area

2.2 Topographic features

For the extraction of some topographical features of Kodagu district such as Slope, elevation, Aspect, contour and drainage good quality digital elevation model (DEM) is required. The DEM data used for the extraction and preparation of these maps is SRTM-1 Arc Second Global (Shuttle Radar Topography Mission-1 Arc Second Global). This DEM data is obtained from the Earth explorer. The resolution of SRTM-1 Arc Second Global DEM is 30m.

2.3 Software Tools

ArcGIS 10.5 it is the software which is used for the extraction of topographical features such as Slope, elevation, Aspect, contour and drainage. They are extracted using spatial analysis tools and drainage is extracted using Arc Hydro tools.

2.3.1 To find the topographical features we required maps of following

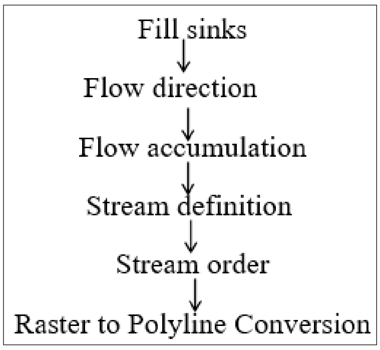
1. Slope
2. Elevation
3. Aspect
4. Contour
5. Drainage

The Slope, Elevation, Aspect and other data are obtained from the SRTM DEM which is downloaded from the Earth explorer. ArcGIS is used in order to prepare the slope, elevation, aspect and other shape files and maps.

2.4 Extraction of Topographical features and Maps Preparation

After the downloading the DEM from Earth explorer portal, the DEM file is added to the GIS software that is ArcGIS software. For the extraction of slope and aspect the Surface tool is used, which is found in Spatial analyst tool box there we can find slope, aspect and contour extraction tools by using these tool slope and aspect are extracted.

For extraction of drainages, Arc Hydro Tool is required, which is an additional setup file which should be downloaded installed separately. By using same DEM file with the use of Terrain pre-processing tools in Arc Hydro tool box then the DEM is subjected for the few steps they are:



The drainage delineation process is based on the 'eight-pour point' algorithm (Jenson and Domingue, 1988) [5] which includes pit filling, calculation of flow direction and flow accumulation grids from DEM. From the flow accumulation grids, stream networks are extracted. Streams are defined wherever drainage areas are greater than the defined threshold value. Sub-watershed outlets are automatically defined on the confluences of the streams and also at the user defined points. Then the obtained raster is converted in polyline using Convert tool and the final drainage network is formed.

After the extraction of these the final step is to mapping the extracted features that includes the adding the, title to the map, North arrow, legend, scale, scale bar and data reference grid and exporting the map with required resolution of image.

2.5 Digital Elevation Model (DEM)

For the extraction of some topographical features of Kodagu such as Slope, elevation, Aspect, contour and drainage good quality digital elevation model (DEM) is required. The data used for the extraction and preparation of these maps is SRTM-1 Arc Second Global (Shuttle Radar Topography Mission-1 Arc Second Global). This DEM data is obtained from the Earth explorer. The resolution of SRTM¬-1 Arc Second Global DEM is 30m (Fig 2). C-band Space borne Imaging Radar and the X-band Synthetic Aperture Radar was modified for the SRTM mission to collect interferometric radar data, which compared two radar images or signals taken at slightly different angles. This technique used single –pass interferometry, which acquired two signals at the same time by using the two different radar antennas. An antenna located on the board of space shuttle collects one dataset and the other dataset from the antenna located at the end of 60m mast that extended from the shuttle. Differences between the two signals allowed for the calculation of surface elevation. This elevation data offer worldwide coverage of void filled data at a resolution of 1 arc second (30 meters).

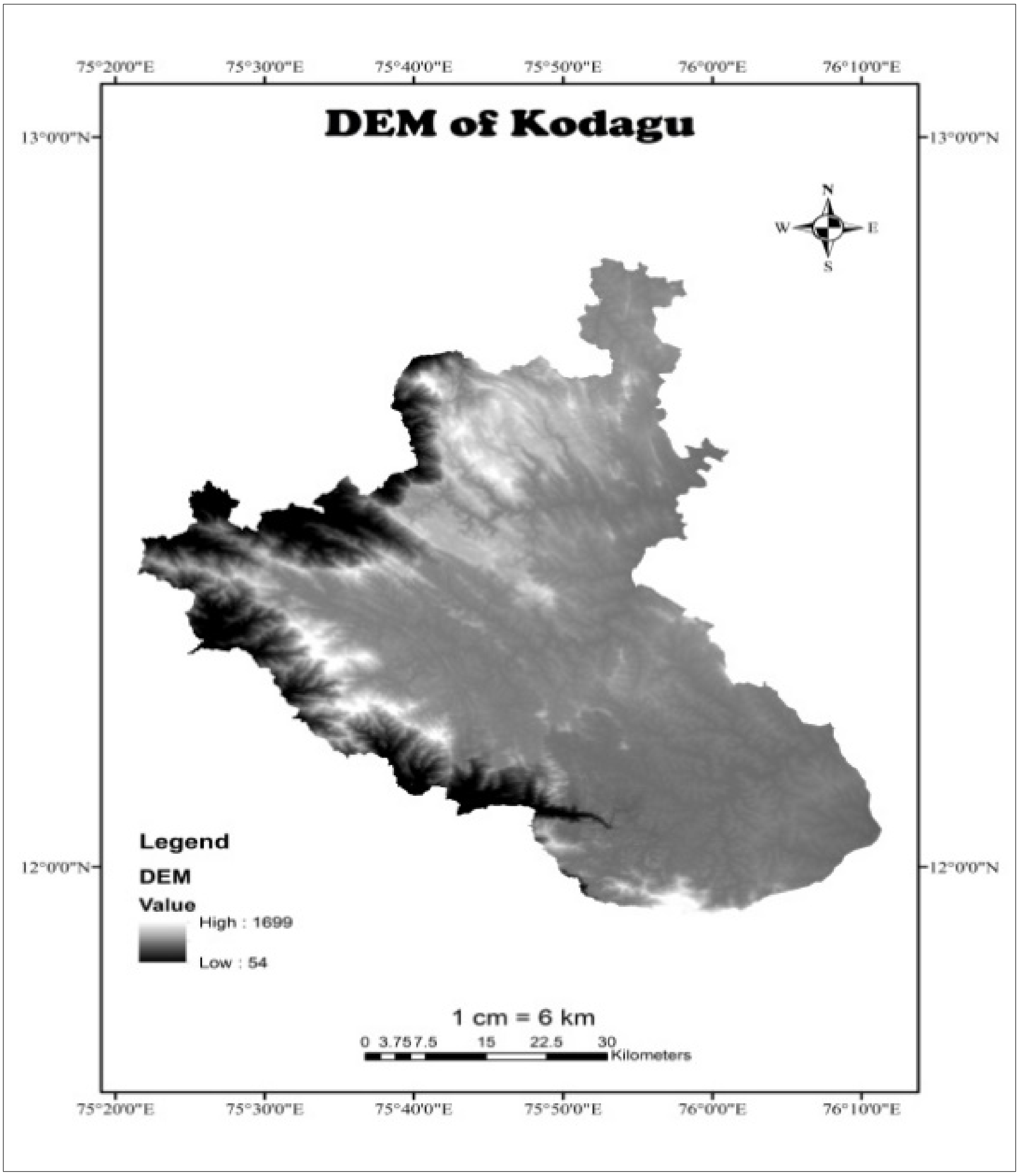


Fig 2: Dem of Kodagu District

3. Results and Discussion

In the present study, the severe landslides were occuried in the different places of Kodagu such as Mangalore-adfMadikeri Highway, Hebettageri, Kaloor, Anjanageri Bettageri, Hattihole, Makkanduru (Fig 3). The elevation of an area can plays a crucial role in the occurrence and potential impact of landslides. As shown in table 1. elevation of the study area varies from 627- 1126 m. Highest elevation of 1126 m was found in Makkanduru and the lowest elevation of 627 m was found at Madekeri – Mangalore Highway (Fig 4). Some authors (*i.e.*, Pachauri and Pant 1992; Ercanoglu and Gokceoglu 2002) [7, 3] reported that the altitude, or elevation, is often used as an indicator of landslide susceptibility. Higher altitudes tend to have steeper slopes, and the increased gravitational force on the slopes can contribute to landslides. Additionally, higher elevations may experience more intense rainfall which can further increase the risk of landslides.

Table 1: Elevation of different elevation of landslide affected areas

Sl. No.	Location	Elevation (m)
1.	Mangalore- Madikere Highway	627 - 825
2.	Hebettageri	820 - 850
3.	Kaloor	915 - 1051
4.	AnjanageriBettageri	885 - 967
5.	Hattihole	960 - 1016
6.	Makkanduru	950 - 1126

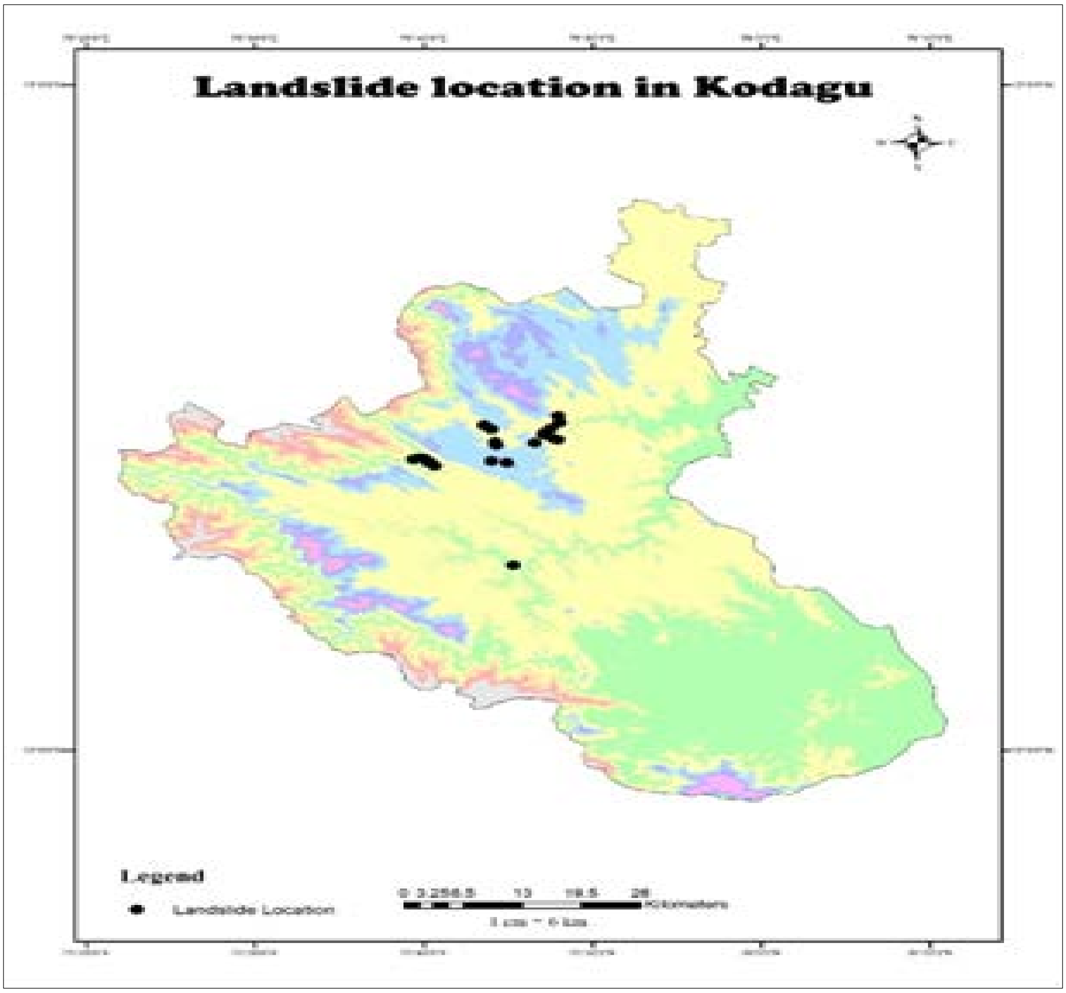


Fig 3: Landslide Location map

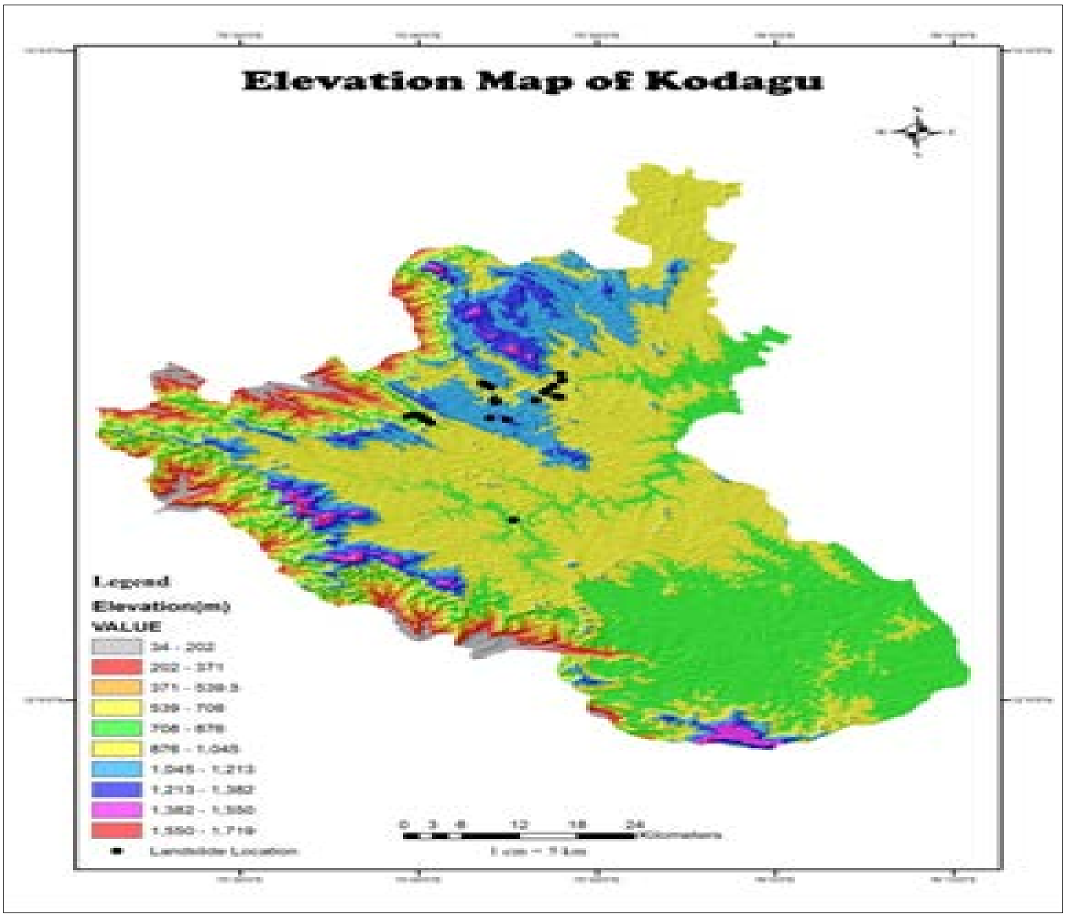


Fig 4: Elevation Map of Kodagu

Table 2: Slope of different of landslide affected areas

Sl. No.	Location	Slope (%)
1.	Mangalore- Madikere Highway	30 – 60
2.	Hebettageri	30 – 40
3.	Kaloor	10 – 20
4.	AnjanageriBettageri	20 – 40
5.	Hattihole	20 – 40
6.	Makkanduru	20 – 40

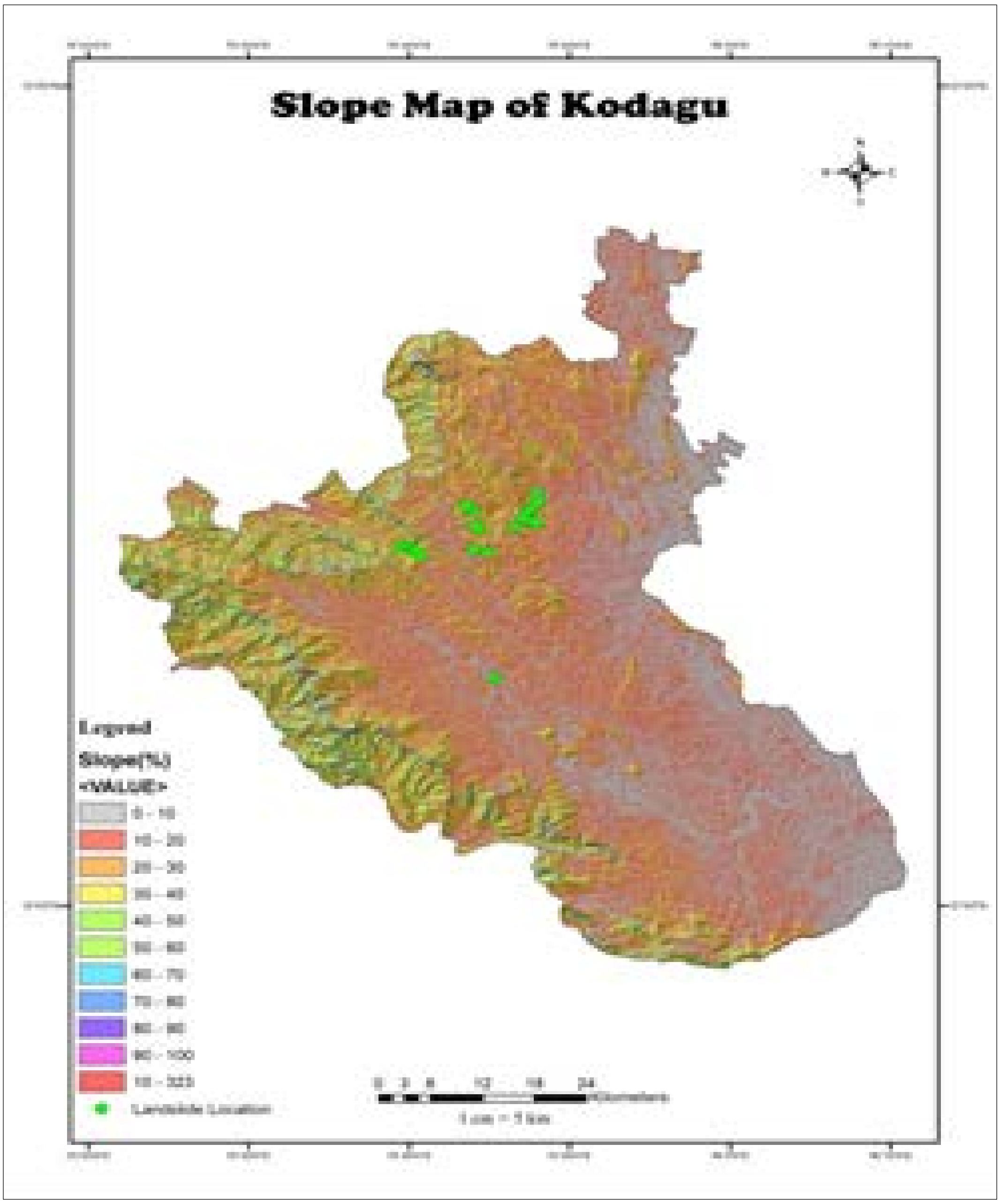


Fig 5: Slope map of Kodagu District

Table 2: Aspects of different of landslide affected areas

Sl. No.	Location	Aspect
1.	Mangalore- Madikere Highway	North-East
2.	Hebettageri	South
3.	Kaloor	South-West
4.	AnjanageriBettageri	South-East
5.	Hattihole	South-East
6.	Makkanduru	East

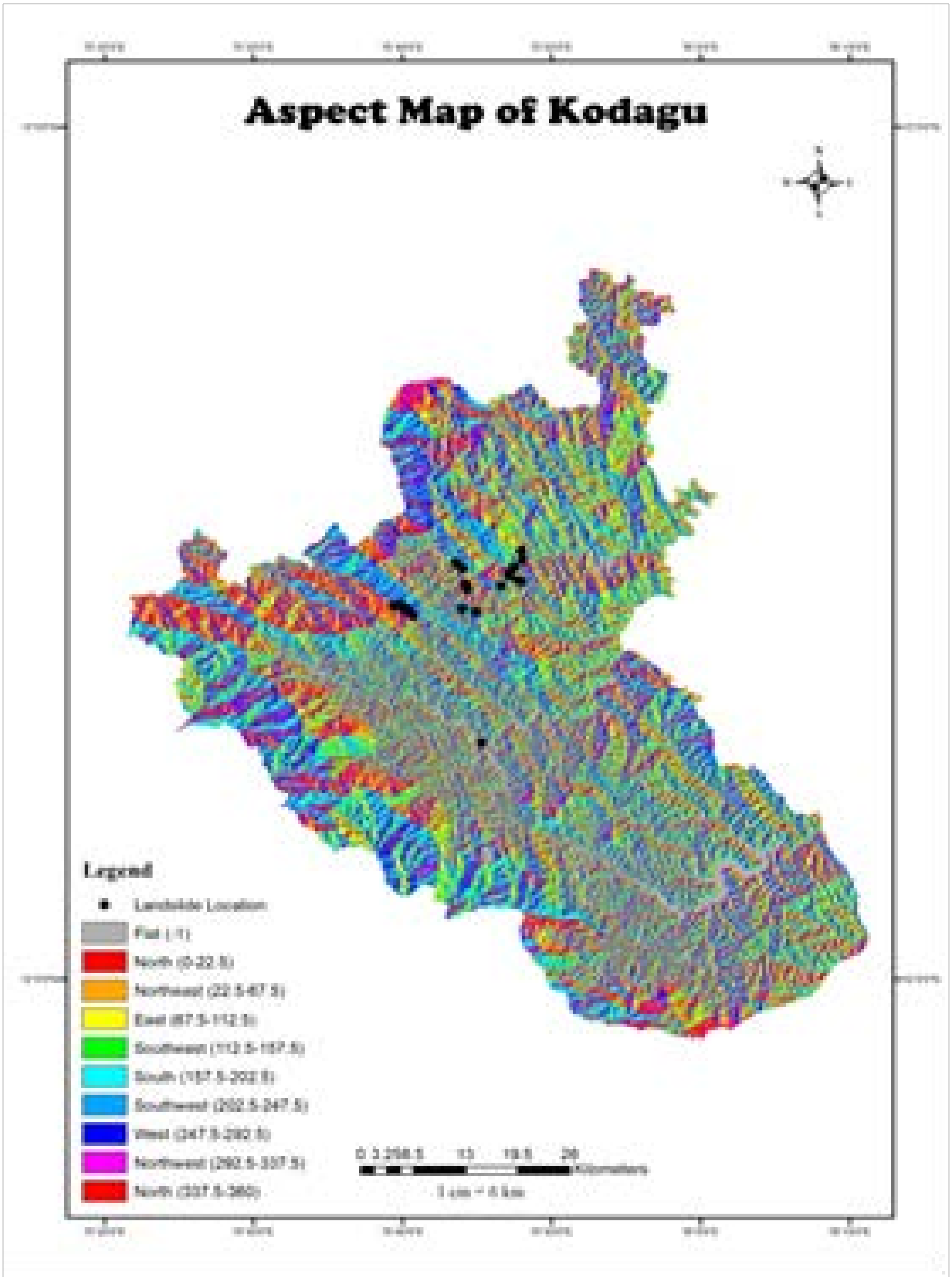


Fig 6: Aspect map of Kodagu

The steepness of the terrain directly affects the stability of the soil or rock. The steeper the slope, the more susceptible it is to gravitational forces that can trigger a landslide. Slope of the study area vary from 10 to 60%. The highest slope was recorded at Mangalore- Madikere Highway and lowest slope was found at Kaloor (Fig 5). Donnarumma *et al.* (2013) [1] reported that landslide area distributions show prevailing slope angles around 10–12 per cent. Different types of slopes have different stability thresholds. Steeper slopes generally require more careful monitoring and planning to prevent landslides and ensure safety.

Aspect is another crucial factor when considering landslides. The results on aspects (Table 3) revealed that the study location such as Kaloor, Anjanageri, Bettageri and Hattihole are having South West Aspect. In controversy the study locations such as Makkanduru, Mangalore- Madikere Highway and Hebettageri are having East, North-East and South Aspects respectively (Fig 6). Similarly, Duman *et al.* (2006) [2] revealed that NW–SE direction have the most susceptible zones prone to land sliding. Aspect plays a role in the distribution of sunlight and moisture on slopes, influencing their stability. Combining aspect with factors like elevation, slope angle, and geological characteristics provides a more comprehensive understanding of landslide susceptibility.

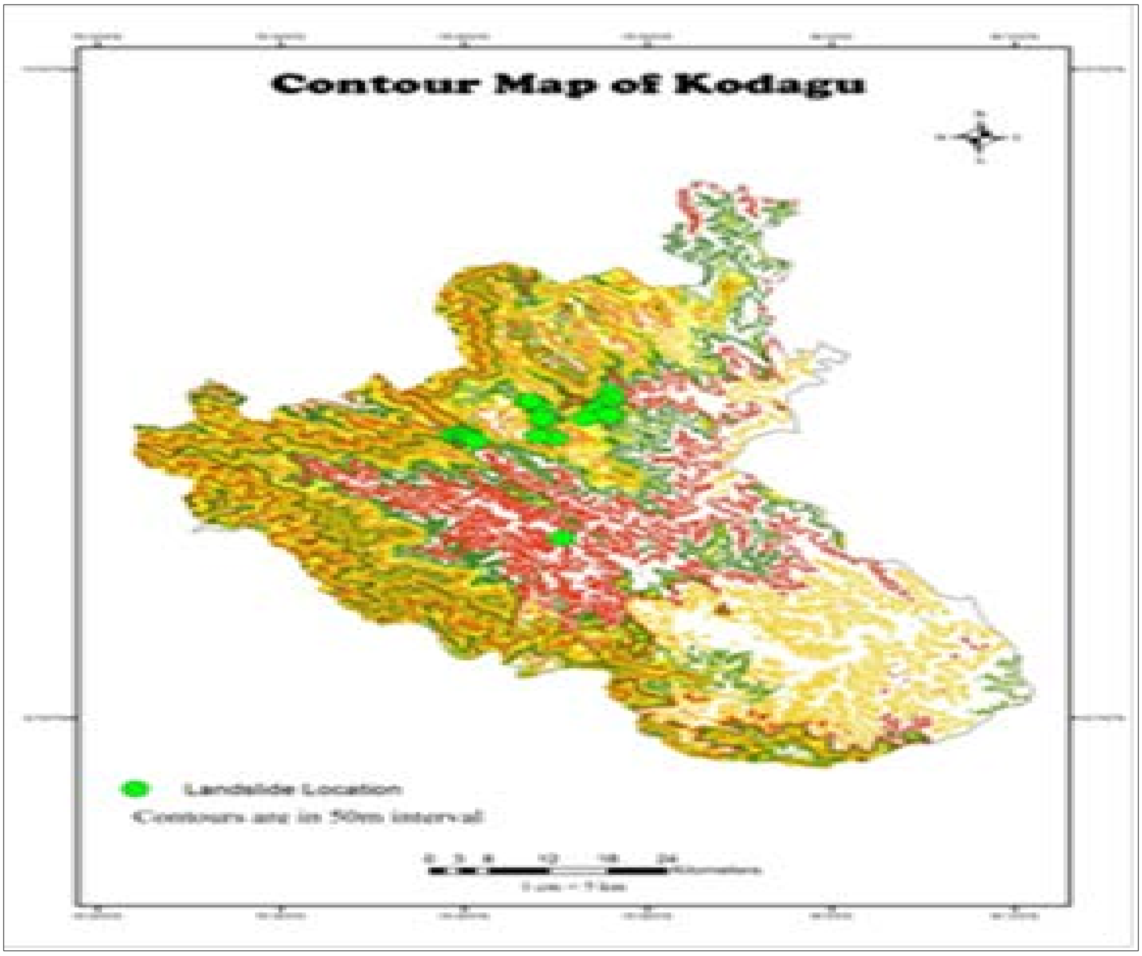


Fig 7: Contour map of Kodagu District

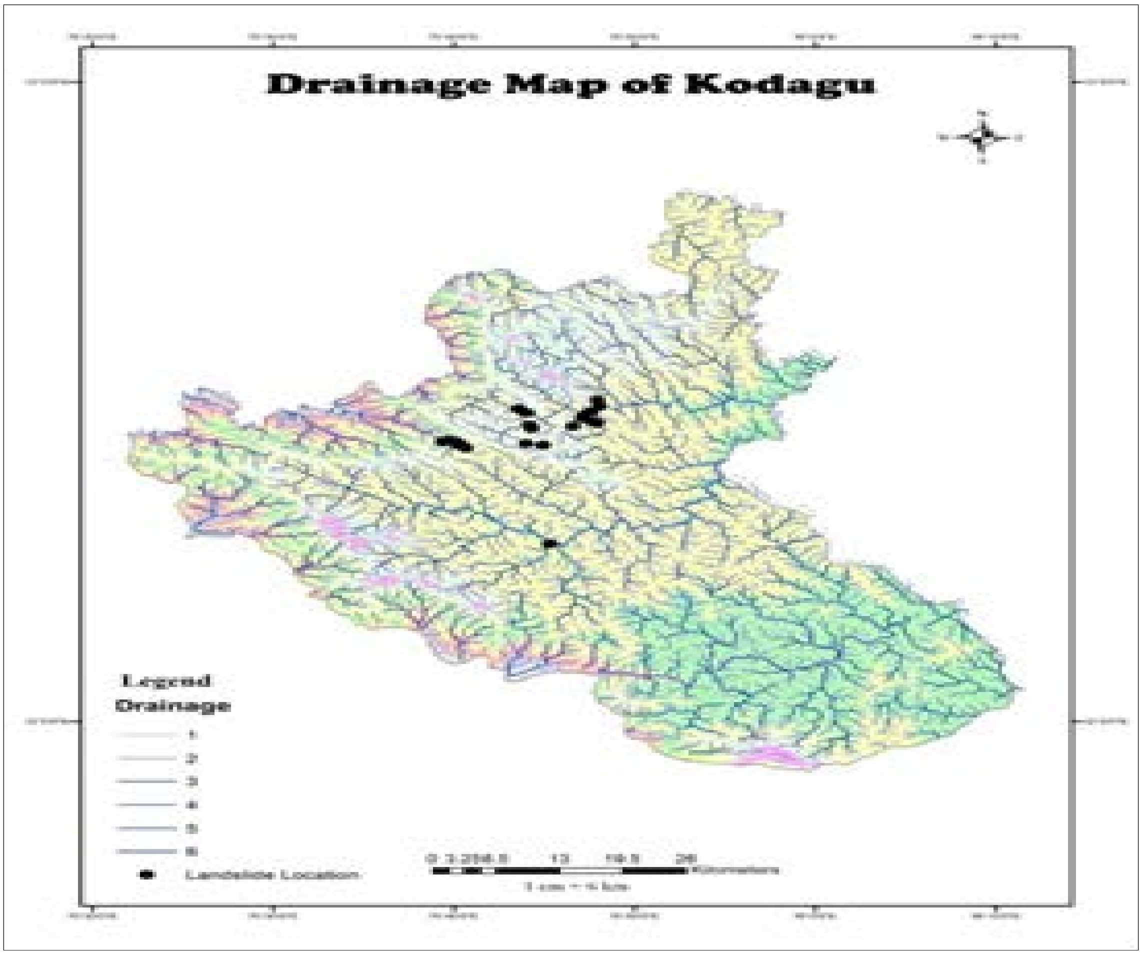


Fig 8: Drainage map of Kodagu

A contour is a line drawn joining the points of equal elevation. A contour map is a topographic map on which the shape of the land surface is shown by contour lines, the relative spacing of the lines indicating the relative slope of the surface. Here the contour value varying every 50 m interval is extracted (Fig 7). Contouring plays a crucial role in assessing landslide susceptibility by providing insights into the topography and landform characteristics of an area. It is an essential tool for understanding the terrain and identifying factors that contribute to landslide hazards. Contour maps also show drainage patterns, such as the locations of rivers, streams, and watersheds (Fig 7). Contour lines that are closely spaced indicate steep slopes, while lines that are more widely spaced suggest gentler slopes. Steep slopes are more prone to landslides, especially when they are composed of loose or poorly compacted materials

Drainage plays a important role in landslide susceptibility and mitigation. Poor drainage conditions can contribute to the increased risk of landslides by saturating the soil and reducing its stability. In the study area, presence of excess water due to continuous rainfall and poor drainage in the soil has decreased the internal friction between particles, reducing the soil's shear strength. It has been observed from the drainage maps that many of the smaller first order streams have dried up reducing the drainage density per unit area. As a result, some of the streams which were earlier of second order have turned up to be first order streams. Some streams are found to change in course flow and direction flow (Fig 8).

4. Conclusion

The extraction of topographical features needs the GIS software, where the process of the extraction is easier. In landslide areas, the de-silting water bodies and deblocking of drainages is need of the hour. Steep slope (>30%) need to be stabilized by bench terracing. There are needs to promote cultivation of deep-rooted indigenous plants in affected and vulnerable areas. Risk of soil erosion will be high if the affected and susceptible areas are left unprotected and hence immediate action towards conservation is needed.

5. References

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