

# **Landslides in Coorg District of Karnataka State**

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**ABSTRACT:** Coorg district in Karnataka state lies in the southern part of Western Ghats with high range hills. The topography of the region is sensitive and any changes in the land use causes landslide or slope failures affecting the population. Thus, the district along with its scenic beauty and pleasant climatic conditions is also becoming known for natural hazards. Infrastructural development in the form of laying new roads and widening of the existing roads involved the modification of slopes thus the equilibrium attained by the nature has been deteriorated. Majority of slopes along the high way pose significant risk dominantly from rainfall-induced slope failures. The study was initiated with the preparation of landslide inventory map by field method. The factors generally responsible for the landslides or slope failures viz., lithology, structure, slope, morphometry, geomorphology, land use/land cover, drainage density, lineament density, rainfall data and soil map were considered and each contributory feature was transformed to a thematic map by using Arc GIS version 10. The study reveals that a large part of the study area comprises peninsular gneisses and these rocks are covered with a thick weathered mantle. Most of the exposed sections along highway and the failure surfaces display deeply decomposed peninsular gneiss with or without corestones followed upwards by saprolite. Heavy rains during monsoon season leads to slope saturation by water, decreases the effective cohesion and generates hydrostatic pressures in the soil profile allowing slope failures. Only mitigation measure to reduce the risk is to construct retaining structures. The study owes the frequent slope failure in the study region to the combined natural and anthropogenic causes.

**KEYWORDS:** Landslides, Weathering, Coorg district, Granitoid rocks, GIS.

## **I. INTRODUCTION**

Landslides are one of the major geological processes and they become hazards when they have a direct effect on the human life and their properties. The term 'landslide' is defined as "the movement of a mass of rock, debris, or earth down a slope" (Cruden, 1991) under the influence of gravity. The movement of the mass may be slow or rapid. Some mass movement processes, such as soil creep, are almost imperceptibly slow and diffuse while other, such as landslides, are capable of moving at high velocity, discrete, and have clearly identifiable boundaries, often in the form of shear surfaces (Crozier, 1989).

The Coorg district in Karnataka state with distinctive geomorphological, geological, hydrological and meteorological characteristics has long been known for landslides in selected areas during certain months of a year. These events failed to attract the attention of the researchers due to various reasons including insignificant damage caused, thick vegetation, wild life, lack of exposures, high hillocks, accessibility, thick soil cover. Of late, the number of events increased in proportion to the human activity and also the amount of damage caused has also increased. Several factors although have a bearing on slope failures or landslides, topography, climate, slope angle and anthropogenic activities play a significant role. In the neighbouring state Kerala, located further south of the present study area, the causative factors for the acceleration of landslides have been attributed to anthropogenic disturbances such as deforestation, terracing and obstruction of ephemeral streams and cultivation of crops lacking capability to add root cohesion in steep slopes (Kuriakose et al., 2009). In this paper an attempt has been made to study the landslides in Coorg district, their types and correlate them to the degree of weathering of the granitoid rocks in the area. The study started with an inventory map

for the hazard. Knowledge on the causative factors was derived from the geomorphic, topographic, geologic, meteorologic and hydrologic parameters that were integrated in a GIS framework.

## II. STUDY AREA

Coorg district is situated on the eastern and western slopes of the Western Ghats, carpeted with lush green forests, plantations and cultivated valleys. Geographically, it lies on the southwestern border of Karnataka State and geologically it is situated in the SW part of the Western Dharwar Craton (WDC). The study area lies between North latitude  $12^{\circ} 19' 17''$  and  $12^{\circ} 43' 36''$  and East longitude  $75^{\circ} 22' 29''$  and  $76^{\circ} 19' 15''$  in the 1:50 000 Survey of India toposheet number 48 P/6, P/7, P/10, P/11, P/14, P/15 and 57D/2. The study region (Fig.1) located in Coorg district covers an area of about 1252 sq. km. The area of investigation consists of chains of hill ranges covered with lush green forests, plantations and cultivated valleys.

The study area comprises of highly dissected, undulating and moderately sloping structural hill ranges in addition to hillocks of denudational and weathering origin. Some of the hillocks are highly dissected with sharp ridges and steep slopes, whereas some areas are characterized by gentle and low dissected hillocks. This indicates that the topography is immature. High elevated areas are more susceptible to landslide than low elevated areas. The inventory study of landslides reveals that the maximum location of landslides are in dissected plateau units found at higher altitudes where lithology of that area is made up of Peninsular Gneiss.

After applying all these 4 steps, we get a filtered image that contains only text regions.

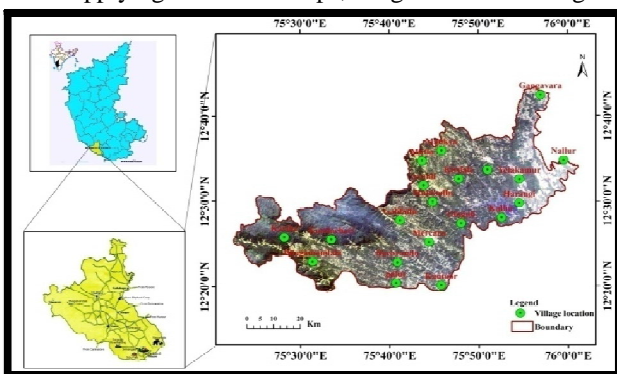


Fig.1. Location map of the study area

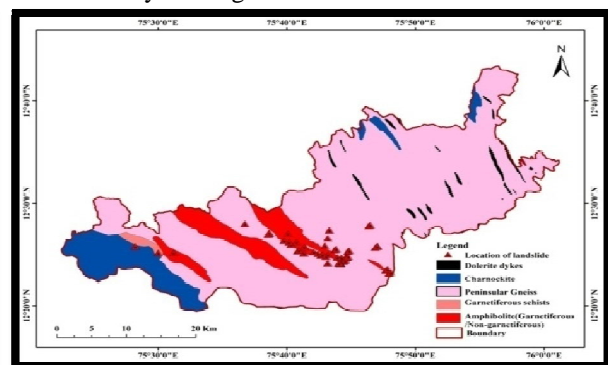


Fig. 2. Geological map with locations of landslide incidences

Geologically, the study area comprises of Archaean group of rocks represented by older group of rocks and Peninsular Gneissic Complex (PGC). The older rocks belonging to Sargur Group are represented by garnetiferous sericite schists and garnetiferous/non-garnetiferous amphibolites amidst the vast expanse of Peninsular Gneisses. Garnetiferous schist occurs in the form of a patch bordering granulitic facies rocks which are represented by charnockite in the western part of the study area. Whereas, garnetiferous/non-garnetiferous amphibolites largely occur essentially in the form of ridges running parallel to each other and trending in NW-SE direction (Fig.2). PGC is represented by biotite and hornblende gneisses with quartz and pegmatites veins. This is the major rock unit in the study area.

Rainfall has the direct bearing on the number of landslide incidences in the study area. The study area has characteristic tropical climate with heavy rainfall and cool summer. The last 30 yrs (1984-2013) data reveals that that the western half of the Kodagu district has received highest rainfall (average minimum 5000 mm and maximum 6766.70 mm) as per the records of Talacauvery, Bhagamandala rain gauge stations. The iso-hyetal map of the study region depicts that majority of landslide incidences have occurred in the areas which have received more than 5490 mm annual rainfall (Vinutha, 2015).

On the surface, the soil cover of the district consists of lateritic debris found in different stages of weathering developed over granitic gneisses of the region. The valleys and slopes are covered with deep lateritic clayey soils and deep lateritic gravelly clay soils. In the eastern zone medium deep red clayey soils, deep red clayey soils and deep alluvial

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

clayey soils predominant. These get water logged during monsoon and deep cracks appear during the summer months. In the central zone loamy soils are predominant. In the western zone, the soil is highly leached and being lateritic in content, tends to be quite shallow.

### III. METHODOLOGY

A map of existing landslides serves as the basic data source for understanding conditions contributing to landslide occurrence (<https://www.oas.org/dsd/publications/Unit/oea66e/ch10.htm>). A landslide inventory map records the location and, where known, the date of occurrence and the types of mass movements that have left discernable traces in an area (Guzzetti et al., 2000). Normally such a map is prepared by the interpretation of aerial photography and field examination of selected locations. However, the present investigators compiled the data by field methods alone due to the thick vegetation. In addition to the inventory of landslides, weathering profile of granitoid rocks at various locations was studied.

### IV. RESULTS AND DISCUSSION

Landslide inventory map of the study region was prepared by carrying out detail field studies. The locations of the landslide incidences are shown in Fig.3. More than 80 events of landslides have been recorded by field studies (Vinutha, 2015) and majority of the landslides incidences have occurred in the areas covered with granitoid rocks and their weathering products. Landslides in the area are of various sizes from local surface slides to complex landslides involving an entire slope. From the historical data and the present study, it was found that majority of the debris slide is triggered by heavy rain fall in the preceding hours. Apart from the climatic conditions, other factors responsible for the triggering of landslides in the study area are land use and human activity in the form of excavation in a slope for road widening. Flageollet et al., (1999) are of the opinion that human action and land use are generally considered to increase liability to landsliding, the real triggering factors being the rainfall or the seismic events.

Landslides are divided into various types depending on the kinds of materials involved and the mode of movement. In the present study, the classification (Table 1) proposed by Varnes (1978) based on two attributes (1) type of material and (2) type of movement has been adopted to identify the type of landslides in the study area.

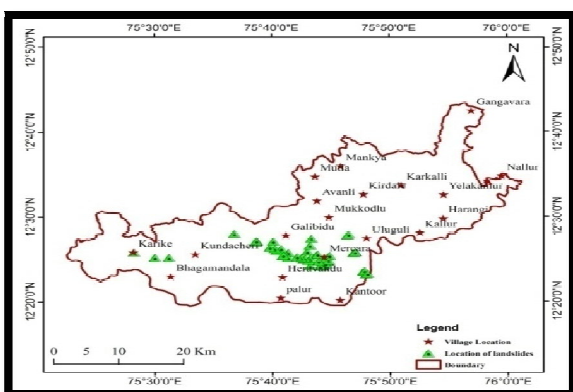


Fig.3. Landslide Inventory map



Fig.4. Sheeting joints in granite

Durgin (1977) gave four-stage classification of weathering products of granites (Table 2); (1) fresh rock, (2) corestones, (3) decomposed granitoid, and (4) saprolite. He estimated that the fresh granitic rock contains a maximum of 15% weathered material that forms in the joint system. The corestone stage ranges from 15 to 85% weathered rock enclosing remnants of fresh rock. Decomposed granitoid consists of 85 to 100% weathered disintegrated rock that can

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

be broken down into granules. Saprolite is a fine-grained residual rock that generally has an upper lateritic layer. In the present study area, all the four stages of the weathering products of granitic gneisses are seen.

Table 1. Varnes' classification of slope movements (Varnes, 1978).

Type Of Movement		Type Of Material		
		BEDROCK	Engineering Soils	
			Predominantly coarse	Predominantly fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth topple
Slides	Rotational	Rock slide	Debris slide	Earth slide
	Translational			
Lateral spreads		Rock spread	Debris spread	Earth spread
Flows		Rock flow (deep creep)	Debris flow (Soil creep)	Earth flow
Complex	Combination of two or more principal types of movement			

Table 2. Weathering–mass movement relationships (after Durgin, 1977)

Stages of weathering	Mass movements
Saprolite (thoroughly decomposed rock)	Rotational slides, slumps
Decomposed granite (>85 % weathered rock, 15 % of fresh rock left)	Debris flows, debris avalanches, debris slides
Corestone stage (15–85 % of fresh rock left)	Rock fall avalanches, rolling rocks
Fresh rock (<15 % of weathered material along joints)	Rock falls, rock slides, block glides; debris avalanches and slides over sheeting surfaces

Rockslides on minor scale are noticed all along the road connecting Madikeri to Virajapet in the Coorg district. According to Terzaghi, (1962a), the susceptibility of fresh bedrock to rockfalls, rockslides, or block glides depends upon a number of conditions, including (1) the angle of shearing resistance of the jointed rock, (2) the effective cohesion, and (3) the seepage pressures of water in the joints in such cases, the angle of inclination of rock joints is considered. Sheeting in granite often creates joints that are sub parallel to the ground surface, with critical slope angles as low as 30° to 40° (Fig. 4). Slabs of sheeted granite may slide down a slope as block glides (Terzaghi, 1962b). As weathering progresses, decomposed granite forms along the joint planes and decreases the effective cohesion while increasing the void ratio. As the study area receives heavy rain fall during monsoon season, it is possible that the hydrostatic pressures developed in joints due to infiltration of water might have contributed for the loss of shear strength thus bringing down the rock mass (Fig. 5).

The weathered zone develops outward from the joints and isolates blocks or boulders of fresh rock to form corestones (Durgin, 1977). In some areas, corestones become remnants on the ground surface and may roll down slopes during rainy periods, causing extensive damage (Barata, 1969; Da Costa Nunes, 1969 cited by Durgin, 1977). The type of



## International Journal of Innovative Research in Science, Engineering and Technology

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Fig. 5. Landslide along Madikeri-Virajpet road



Fig. 6. Core stones in granite saprolite

slide most characteristic of this weathering stage is the rockfall avalanche. This type of movement (Fig. 6) is seen along the SH-88 road shortly after Mercara town, on the way to Sulliya.

At the advanced stage of weathering, K-feldspars and biotite in granitic gneisses decompose first thus increasing the porosity and permeability of the rock. As a consequence to this, the shear strength and bulk density as well as the cohesion of the decomposed rock are lost. Hence during rainy days, the saturated decomposed rock offers no resistance and gets detached and the mass is brought down in the form of debris flows. This type of debris slides occur all over Coorg district. Although plantation has decreased the number of such incidences by stabilizing the slope, road widening and new road building and change in the land cover have contributed largely for the instability of slopes.

In the final stage of weathering of peninsular gneiss a brownish saprolite with a cover of laterite is seen in most part of the study area, especially in the western part. The thickness of this layer varies however in most part; it is deep measuring more than 15 meters. A slope failure characteristic of saprolite is the slump or rotational slide (Durgin, 1977). In the central and western parts of the study area, where in the deep weathering has produced thick saprolite layer, frequently witnesses slump of the soil mass (Fig. 7). At places, retaining walls have been built (Fig. 8) both by government authorities and residents to arrest the movement of the soil, however excavating saprolite for construction of the buildings, causes slope failures.

### V. CONCLUSION

Many factors which cause slides include geology, weathering, water content, vegetation, slope angle, and human actions. Although landslides usually occur on steep slopes, they also can occur in areas of moderate to low reliefs. The factors responsible for the cause of landslides can be classified into two types as (1) natural and (2) anthropogenic. Almost every landslide has multiple causes which may be natural, anthropogenic or combined. The triggering of landslides in the region studied bear obvious relation to climatic conditions. Majority of the events have occurred during the SW monsoon months of June and July and on minor scale during NE monsoon i.e., in the month of October and November. Like elsewhere in the world, in the study area also there is a strong correlation between the rain fall and the landslides. It may be reasonably expected that the properties of the slope-forming materials, such as strength and permeability that are involved in the failure, are related to the lithology, which therefore should affect the likelihood of failure (Dai and Lee, 2002). The topography of the Coorg district is sensitive and any changes in the land use causes landslide or slope failures affecting the population. However rapid rise in population and economic activities owing to which the area is witnessing infrastructural development in the form of civil engineering constructions and development of roads for better connectivity in the area is of great concern as it is causing instability in the hilly terrain.



Fig. 7. Slump of the wet soil mass



Fig. 8. Retaining wall – earth retention system in Mercara town

Landslides in parts of Coorg district may be correlated to the weathering stage of the peninsular gneisses. In the study area, the transition of fresh rock of peninsular gneiss to saprolite has been divided into four stages; (1) fresh rock, (2) core stone, (3) decomposed granitoid and (4) saprolite. Granitoid rocks in the hilly terrains are normally microscopically sheeted due to unloading of stress. These microsheets generally strike parallel to major slope surfaces and gently dip down slip forming cataclinal over dip slopes (Chigira, 2001). The cataclinal over dip slope accelerated the movement of microsheets granite thus causing rock fall in the region. Rock falls in the region are essentially translational slides wherein the surface of failure is essentially planar in geometry. Weathered zone develops blocks of fresh rock to form core stones. These roll down slopes during rainy periods causing extensive damage. Mitigation works carried out to reduce the damage both in the Mercara city and all along the highway roads include construction of retaining walls. Surface drainage control works in the form of U- ditches all along the road on either side, restricting development in landslide prone areas, construction of retaining walls with weep holes, providing armored protection with concrete blocks are some of the mitigation measures undertaken by the local authorities.

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