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Study on Landslide in Western Ghats of Kerala

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Abstract
The aim of this paper is to study the impact of Landslide on Western Ghats of Kerala and propose strategies to reduce the disaster. Landslides are one of the most common hazards in the world and about 12% of India's land is under threat of landslides, hence it is important to establish effective management systems to reduce their effects. The first step in implementing management plans is to map the allocation of land and landslides and to identify potential hazards. The objective of this Study is to implement the first step in managing the risks of landslides in the state of Kerala, India, by conducting easily accessible landmarks that indicate the risk of landslides in each state. Over the past few years, especially the Western Ghats of Kerala have been responsible for many landslides during the rainy season, from June to November causing severe damage to roads, houses, agricultural fields and forest centers, etc. shows that about 40% of the state lies in the highland region that forms the western slopes of the Western Ghats. The main type of Landslide that occurs in Kerala is the flow of debris, although other forms such as debris slides and rock falls are also common. This study is made up of 3 stages. The first phase deals with the Landslide Hazard zonation of India. The second phase includes the introduction of the Study Area which is being researched through Physiographic Division, Climate & Drainage and Change in Land use & Land cover. The final section discusses the profile of the Kerala Landslide, cover details pertaining to the 13 landslide-prone districts of Kerala, Recent Landslides that had happened due to Mega floods in Kerala 2018 and Highlights each district.

Keywords: *Landslide, Western Ghats, Debris Flow, Kerala, Hazard zonation, Land use, Land cover*

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I. INTRODUCTION

The catastrophic landslide has continued to intensify in Kerala for decades. Fortunately some regions have already made progress in developing risk management systems. Landslides are major threats to human health and property. They are caused by a combination of natural and human causes. *(Tanya, 2001).* About 15% of India, including the Himalayan highlands, the Meghalaya plain and the Western Ghats, is prone to land degradation *(NDMA, 2009).*

Kerala is one of the most populated states in India. It is a small strip of land, where 47% by the most prominent orographic feature of peninsular India, the Western Ghats mountain chain. Landslides have been caused extensive property damage in Kerala. Between 1961 and 2013, more 270 precious lives have been lost in 67 major landslides. Kerala is in danger of being attacked the risk of landslide. Kerala has a population of 860 people per square meter compared to Uttarakhand with a population of 189 per square.

For maximum performance, Landslide Risk and Hazard zoning activities must be included in the complete system, which will enable and support alternative control systems.

The purpose of all land use planning activities is to effectively manage the risk of landslides in fragile mountainous and mountainous areas so that losses due to landslides are significantly reduced. *(Fell et al. 2005).*

II. LANDSLIDE HAZARD ZONATION

A general landslide hazard map of India shown here marks the areas, in which landslide incidences are more. The Himalaya Mountains in the Northern side and Western Ghats in the south side of the country are more prone to the disaster. Many thematic maps with parameters like geology, geological structures, landforms, land use & land cover, slope, drainage, elevation and aspects of the area are needed for this purpose. Remote sensing and GIS plays a important role in the preparation of Landslide inventory, Hazard zoning maps of the area.

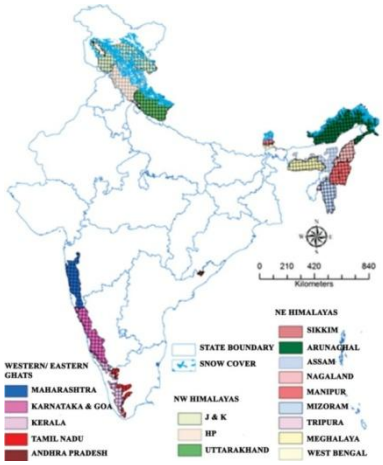

Figure1: Landslide Hazard Zonation Map of India

2.1 STUDY AREA

The Western Ghats is the mountain range that runs along the western coast of India, from the Vindhya-Satpura ranges in the north to the southern tip. That is the Western Ghats stretches from Gujarat to Tamil Nadu with the tallest peaks in Kerala. With 8841 feet the highest peak falls in Idukki district of Kerala. Western Ghats has immensely rich variety of vegetation including scrub jungles, dry and moist deciduous forest, semi evergreen and evergreen forests and grassland in the lower altitudes.

The total area of Western Ghats in Kerala is 28008 Sq.km and end to end length is 450 km. The maximum and minimum width in Kerala is 90 km and 3 km respectively. There is a gap of Western Ghats in Palakkad district having 30 – 40km which is commonly called as Palakkad Gap.

Figure 2: Location of the Study Area

2.2 PHYSIOGRAPHY

The Eastern Highlands, region of Kerala formed by the Sahaya Mountains. The average elevation of this region is about 900 m and has a number of peaks which can reach up to 2000 m. It covers the total area of 18650 sq. km which is 48 % of total area of the state. Anaimudi with an altitude of 2694 m (8842 ft) is the highest point in the state and also the highest point in the South India. As it is one of the largest cardamom producers in the world, the region is often referred as the Cardamom Hills. Most of the river which drains the Kerala originates for this region.

The Central Midlands is the area found between the Sahaya Mountains and the coastal lowlands. It is fully covered up of undulating hills and valleys and spread over the area of 16200 sq. km which is about 41 per cent of the total area of the Kerala state. This region is known for intensive also known as the Coastal Plains, covers a total area of 4000 sq. km and comprises a network of interconnected canals, lakes, estuaries and rivers known as the Backwaters of Kerala.

2.3 CLIMATE AND DRAINAGE

Rivers of varying lengths and widths and its tributaries mainly constitute the drainage system of the State. They are monsoon fed and fast flowing because Kerala has a steep slope towards the Arabian Sea. Out of the 44 rivers, 41 originate from the Western Ghats and flow towards the west and drains to the Arabian Sea.

Kerala experience an annual rainfall of 3000mm of which 65% are from SW Monsoon and 22% are from NE Monsoon and experience and annual temperature of 27° C.

2.4 LAND COVER

The temporal variation of land covers as shown in the figure 3 and shows 69.10% in the year in 1991 and 66.72 % in the year 2014. The non vegetation shows an increase in the Western Ghats region from 30.90% to 33.28% in the year 2014 with a decrease in area from 45402.62 Sq.km to 22646 Sq. km. The spatial- temporal land use change from the year 1991 to 2014 is shown in the figure.

The agriculture area has increased from 7.30% (1991) to 10.39% (2014) and area under plantation has increased from 11.58% (1991) to 17.38% (2014) showcasing the variation of land use pattern caused by the human activity and resource utilization.

The rapid change of urbanization in the Western Ghats region for commercial and economic purposes by clearing high bio diversity areas affecting the habitat of species of flora and fauna. The development of railway lines and hydroelectric power project add to the degradation of natural resources. The conversion of land for alternative land use pattern is due to expansion of agriculture and plantation activities accompanied by mining activities as well.

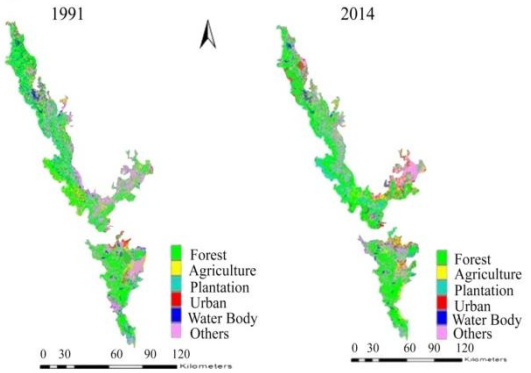

Figure 3: Land cover/Land use Map

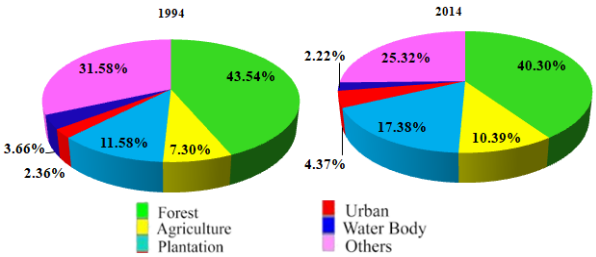

Figure 4: Temporal Variation of Land use/ Land Cover

2.5 LANDSLIDE HAZARD PROFILE OF KERALA

The In Kerala, landslides commonly occur in localized areas of the Western Ghats region where the slope is steep and the soil is over saturated as a result of prolonged rainfall. Case studies by CESS show that most of the events are of debris flow type triggered by excess rainfall and are influenced by terrain factors like slope, overburden thickness, land use, relative relief, disposition of streams, landform at micro level etc. The area of the state is about 38863 sq.km of which 40% lies in the highland region forming the western slopes of Western Ghats. A considerable part of all districts of Kerala except the coastal district of Alappuzha falls within this region. The slope in the Western Ghats region is generally steep to very steep with plateau edges highly indented having > 25° slope. It causes landscape changes, threat to life and destruction of property. The south Indian state of India, Kerala lying in the lap of the mountain range of Western Ghats faced one of its most devastating disasters during the landslides of 2018. The unabated rain from June to August of 2018, triggered thousands of debris flow, landslips, landslides, mud slips, soil piping and subsidence in 12 out of 14 districts of Kerala. Death toll reached 155. Many economic sectors, mainly the agricultural sector faced an irrevocable loss.

The Western Ghats running throughout the length of Kerala, suffers from frequent landslides during the monsoon season which happens twice a year (South West monsoon and North East monsoon). About 8% of area in the Western Ghats has been identified as critical zones for landslides. The annual rainfall in Kerala is about 3000 millimeter whereas it exceeds 5500 millimeter in highlands. Between June 1st and August 26th of 2018, rainfall was 24% more than the usual value for that period.

Unlike other natural hazards landslides are caused by many factors like slope failure, heavy rainfall, soil depth, earthquake, clap of thunder and anthropogenic activities. Anthropogenic factors include loading crest of the slope, excavation at toe of the slope, deforestation, quarrying, mining and land use pattern. However the principal triggering factor is the rainfall.

The State received an excess of 96% during the period from 1st to 30th August 2018, and 33% during the entire monsoon period till the end of August. . The 2nd stage forecast issued on 30th May 2018, the prediction was only of 95% of LPA (5% less than long period average) during the month of August, while the state received 96% excess rainfall.

This unpredicted excess intense rainfall spell have caused significant damage to life and property, the details of which is given in the subsequent chapters. Bureau of Indian Standards IS 4987:1994 prescribes the requirement of 256 rain gauges in the state to be deployed by the nodal agency recognized for the purpose in the country. The State is in receipt of daily rainfall data from 68 rain gauges every 24 hours, which impede the ability of the State to concurrently monitor the spatial distribution and intensity of rainfall.

Kerala is prone to landslides. The Kerala State Disaster Management Plan identifies 14.4% of the State as landslide prone. The Land Revenue Department reported 331 landslides that have occurred in Revenue land. In the month of August, 104 individuals have lost their lives in landslides in the State. Numerous landslides are reported to have occurred inside. Historically, landslides of Kerala are of debris flow type and confined to certain catchments. However, in this unpredicted and unprecedented rainfall, there were numerous deep seated landslides, rock slides and landslips. Figure 5 shows the locations of 331 landslides that occurred in Revenue land in the state.

Table 1: The Number of Landslide Classified by Types in Each District

DISTRICT	DEBRIS FLOW	SOIL SLIDE
Thiruvanathapuram	3	1
Kollam	9	1
Pathanamthitta	92	13
Kottayam	65	11
Idukki	679	1421
Ernakulam	96	11
Thrissur	234	20
Palakkad	699	92
Kozhikode	204	18
Malappuram	358	66
Wayanad	252	68
Kannur	120	19
Kasargod	5	19
Total	2816	1760

The movement of a mass of rock, earth or debris down a slope is scientifically called a mass wasting. Landslide is one of the types of mass wasting observed in nature. Debris flow, landslips, rock fall, slab slide, soil piping, land subsidence etc. are some other types that happened in the state. In Kerala, the most commonly observed types of mass wasting are debris flow (Urul pottal) and landslips (Mannidichil).

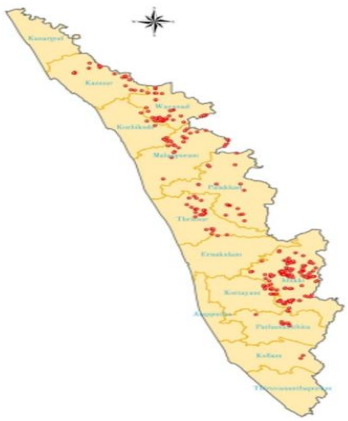

Figure 5: Location of Landslide Occurred in August 2018

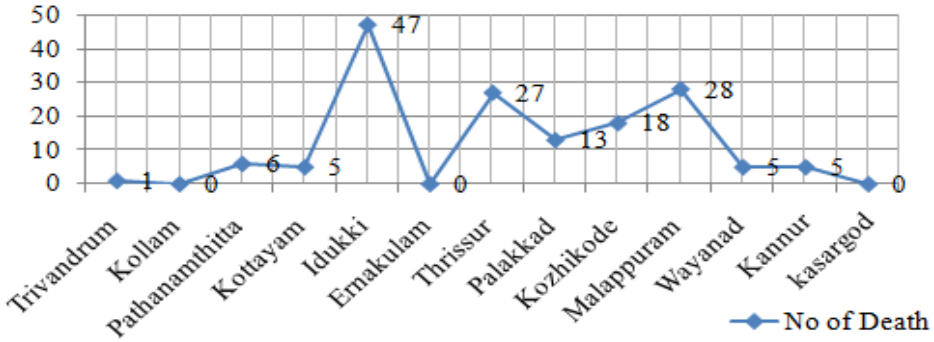

Figure 6: Death Toll District Wise from June to August 2018

2.6 RECCOMENDATIONS – GADGIL COMMITTE

1. Establishment of Western Ghats Authority.
2. No new power plants in the sensitive zones.
3. Organic Agricultural practices.
4. Roads and constructions only after study of environmental consequences.
5. Red and Orange industries are not to be allowed in Z1 and Z2.
6. To stop illegal mining and not to give permission for new mine zones in Z1 and Z2 in the Western Ghats.
7. Recommended a national level authority with counterparts at the state and district level.

2.7 RECCOMENDATIONS – KASTHURIRANGAN COMMITTE

1. Banned development of any township or construction over 20000 Sq.km in ESZ
2. Complete ban of mining and quarrying activities
3. Banned red category industries including thermal power plants
4. Hydroelectric projects can be initiated obeying terms and conditions. Strengthening the existing framework of environmental clearances and setting up of a state of the art monitoring agency.

III. ANALYIS AND FINDINGS

1. The Western Ghats are land areas which are more prone to landslides after the Himalayas, which are home to many biodiversity and that is globally approved.
2. The land use and land cover pattern undergoes changes year wise as a result of urbanization on the Western Ghats.
3. Kerala being more prone to landslides during monsoon, the debris and soil slide are major type of landslides in the study area and Idukki district is being very prone to major landslides.
4. Total 10 taluks are very prone to landslide which is highly vulnerable i.e. population density is greater than 10000.
5. The study areas are included in the Ecological Sensitive Areas of Gadgil and Kasthurirangan in which they are recommend various actions to protect the Western Ghats.

IV. STRATEGIES AND MITIGATION MEASURES

4.1 STRATEGIES

1. Strategies for land use planning framework in the Areas.
2. Strategies for Multi hazard zoning in the prone Areas.
3. Strategies for inventory mapping using remote sensing and GIS.
4. Strategies for protecting existing development.

4.2 MITIGATION MEASURES

The retaining walls are structures designed to restrain the soil. They are normally used in areas with steep slopes or where the landscape has to be shaped severely for construction or engineering projects.

A sheet pile wall is a flexible wall having negligible weight and weight has no control over the wall stability. The number of occurrences of landslide increases. Need of a preventive or mitigation method is very important and a must in current situation.

Biotechnical soil stabilization is a contrived duplication and amplification of the natural process of soil stabilization and plant regeneration following erosion or slope failure events.

Friction pile is a quite pile foundation. This type of pile utilizes the frictional resistance force between the pile surface and adjacent soil to transfer the superstructure load. Depending on the subsoil strata condition, resistance force due to friction can develop in a definite pile length of on the full length.

Shotcrete retaining walls comprise a special mix of high strength concrete being sprayed at high velocity using compressed air, to form a retaining structure, drain or a wall.

Bench terraces are a soil and water conservation measure used on sloping land with relatively deep soils to retain water and control erosion. They are normally constructed by cutting and filling to produce a series of level steps or benches. This allows water to infiltrate slowly into the soil. Bench terraces are reinforced by retaining banks of soil or stone on the forward edges.

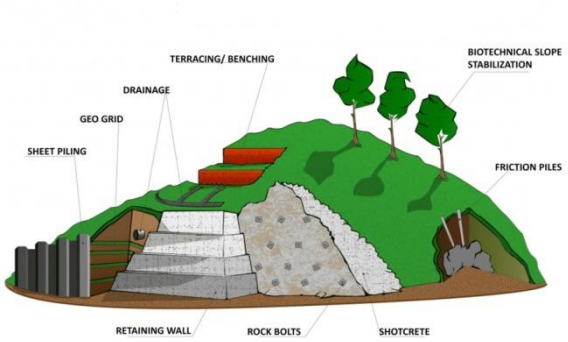

Figure 7: Mitigation Measures for Landslide

V. CONCLUSION

The study was an attempt to formulate the planning strategies and mitigation measures to reduce the impact of Landslides in the prone areas. This was done by studying the existing conditions of the study area, the National level hazard zonation and the Western Ghats of Kerala being the biodiversity hotspot more prone to landslide. The physiographic division were studied, the change in Land use and Land cover were also discussed, one of the major causes of Landslide. The climate and Drainage of the study were also discussed.

One of the aim of the paper is to study the Landslide profile of the Kerala, types of Landslides and recent landslides incidence that had happened due to Mega floods in the Year 2018. While analyzing the study area the landslide vulnerability with respect to population are discussed. The change of land cover and land use analysis in the Western Ghats are also studied to get an impact of urbanization on the biodiversity hotspot of the state. The landslide profile of the study area and the type of landslide, the number of landslide which had happened in the various districts are also mentioned. The two report of Kasthurirangan and Gadgil committee report are also studied in which the various thaluks of Kerala state, are included in the eco sensitive are also studied. The recommendations of the committee reports are also studied.

The final objective was to analyze some preventive measures to mitigate landslide. The various structural and non structural techniques that are used to prevent the landslide in the prone areas are understood. Finally based on these parameters strategies were developed in study area.

The strategies developed helps in facilitating the improved collaboration between agencies that are responsible for land use planning, environment management and private sector. This Study emphasizes the need for landslide hazard zoning which helps to make interventions in the planning level to ensure sustainable development with concern to environment in the study area.

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