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Landslide modelling and susceptibility assessment by soil moisture sensors at Katteri watershed in Southern India

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Abstract. The goal of this investigation is to identify how disastrous occurrences affect the soil in watersheds. As a result, the focus of this investigation is the Katteri watershed in the Indian state of Tamil Nadu's Ootacamund region. The process was examined in the field and the lab using GIS advances and remote sensing. The momentum analysis was started in the Katteri watershed by creating several thematic guides using enrolment maps made with GIS technology that was appropriate for the request. Since most large-scale experiments could not have been conducted in the field, landslide movement at various slopes and precipitation levels was investigated using a lab model of a landslide zone. According to the investigation, more steep inclines with deeper soil are more likely to experience landslides, and precipitation is the primary trigger for these events. The model successfully implemented the use of Soil Moisture Sensors (SMS) as a landslide alarm structure. Avalanche or Landslide Alarm Mechanism may therefore be a useful technique for handling disastrous circumstances.

1 Introduction

Disasters have posed a real threat to humanity in the recent past and in the future. This has been the case despite significant human advancements in science and invention. A disaster is typically portrayed as a catastrophic occurrence. These unfavourable events have a multifaceted impact that affects people's regular schedules. These Landslide have resulted in a significant loss of life and property. Specific change were regular assets that are being set away for people in the future. Both natural and artificial factors can cause Landslide. The most common cause of an avalanche is a significant rainfall. In a generally applicable examination region, this task will probably encourage a passionate catastrophic disaster the executive methodology with practical moderation tactics.

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A process that involved selecting a watershed district, acquiring data, leveraging GIS and advances in remote sensing, and creating thematic maps was used to guide the inquiry. All aspects of sedimentation, landslide susceptibility, and slope stability were investigated. To explore landslide hazards at various slope rates, a research centre model was created. The examination region, to be specific the Katteri watershed arranged 7A/75, is situated inside the Ootacamund area of the Western Steps scope of mountains. The examination region is characterized by scopes of 11º 16'19"N to 11º 24' 40"N, and longitudes of 76 º 40' 40"E to 76 º 49' 25" E. This watershed is accounted for on sheets 58A/11 and A/15 of the Asian nation high sheet review. Avalanche direction A site-explicit investigation on avalanche vulnerability was focused on the Ketti little watershed, which is located on the northern side of the Katteri full scale watershed (1-24).

Sedimentation tests were attempted using the Soil Moisture Sensor (SMS) close to the watershed's channel body. Recent developments in GIS and remote sensing have shown to be helpful in the planning sector. To evaluate the impact of various variables on avalanche rates, it is possible to combine reflection data from several layers. To assist with aspects including slope, geomorphology, lineament, viewpoint, land use, and soil thickness, numerous specialized guidelines have been created. Calculating the appropriate placements and loads led to the creation of a definitive avalanche inclined guide. Throughout the field examination, these guides remained accurate. To establish the slope, soil depth, gift land use, trimming design, channel design, and other factors, a field assessment was conducted. To dissect the basic properties of the soil and create a lab model, soil tests were conducted. The lab model was used in a variety of investigations to better understand the avalanche phenomenon. A lab model and a related application of soil moisture sensor component were used to create a pre-prepared framework. The board's plan, a relevant relief action, and achieving a successful catastrophic event has been developed.

2 Methodology

A process that involved selecting a watershed district, acquiring data, leveraging GIS and advances in remote The Ootacamund / Nilgiris range in height from 900 to 2636 meters above ocean level. Its precise distance and longitudinal measurements are 130 kilometres (Latitude: 11°10.00N - 11° 42.00N) by 185 kilometres (Longitude: 76° 14.00E to 77° 02.00E). The Ootacamund are lined toward the north by Karnataka State, on the west by Coimbatore District, Erode District, and on the south by Coimbatore District, as found in Figure 3.2, and on the east by Kerala State. The geology in the Ootacamund District is rolling and uneven. Slopes going from 16 % to 35 % cover around 60% of the cultivable territory. The methodology approach is depicted in a flow chart as shown in Figure.1.

Table 1. Input data for landslide hazard zonation

Type	Agency Source	Data Collection Techniques	Shape	Scale
Geology	Remote Sensing and GIS	Satellite Imagery interpretation and GSI Maps	Polygon	1:50,000
Soil	Soil Survey reports, Atlas Remote Sensing	Satellite Imagery interpretation with reference to soil survey report		
Land use	SOI Topo sheets and Remote Sensing	Satellite Imagery interpretation and Topographic maps		
Slope (Derived)	DEM	Made from a DEM	Raster	
Aspect (Derived)	DEM	Made from a DEM		

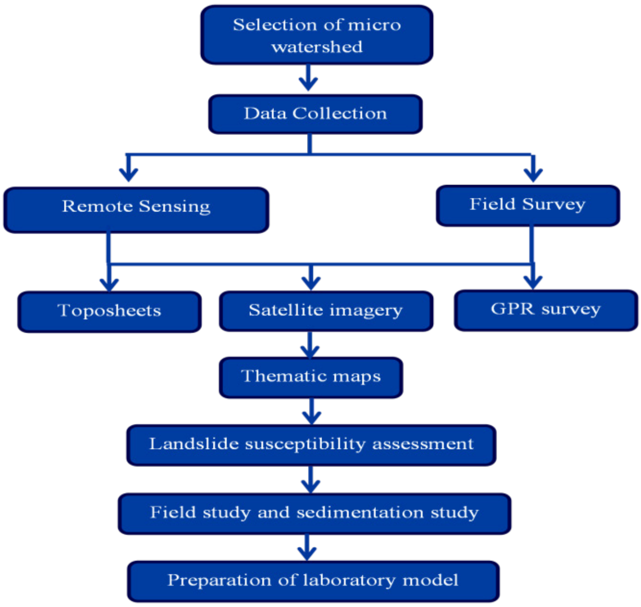

Fig. 1. Methodology

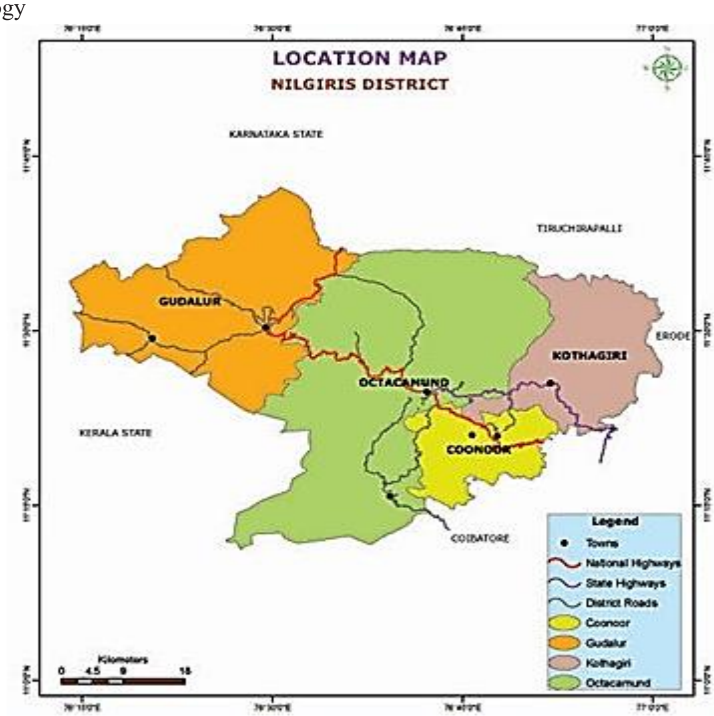

Fig. 2. Katteri Landslide Study Area

After field inspections of the locations of prior, huge landslides in the investigation zone, the landslide vulnerability map has been established. To approve the produced map, previous landslide disaster data from GSI (bar no: 57, 1982) has been used. The areas referred to be significantly and moderately sensitive zones with recognized landslides have a great connection. The examination area is in an area with landslide vulnerability. Slope failures frequently occur in the Ootacamund region of the Indian state of Tamil Nadu due to the intense concentration of precipitation nearby. Both remote, unpopulated locations and densely populated areas are susceptible to slope failure. Most landslides occur in areas that are becoming deforested, developed, urbanized, and migrating. In these areas, more rainfall water may seep through various soil layers and trigger Landslide. Utilizing remote detecting and GIS systems, a landslide vulnerability assessment (LVA) was done for the Ketti micro water shed as site-explicit research identified with landslides. The supporting guidelines for the Ketti Micro watershed were prepared in several thematic maps based on the data and field focus using GIS.

2.1 Land Slide Vulnerability Assessment (LSVA)

Watershed map, Present Land use map, Drainage map, Slope map, Soil map, and Elevation as well as Contour map have been included for this study. This work depended on geographical guides and satellite symbolism from the Survey of India. During field examinations, the pre-arranged guides were defended in the field. At long last, utilizing GIS programs, the entirety of the topical guides was joined to make a Landslide Susceptibility map for the Ketti miniature watershed shown in Figure 3.

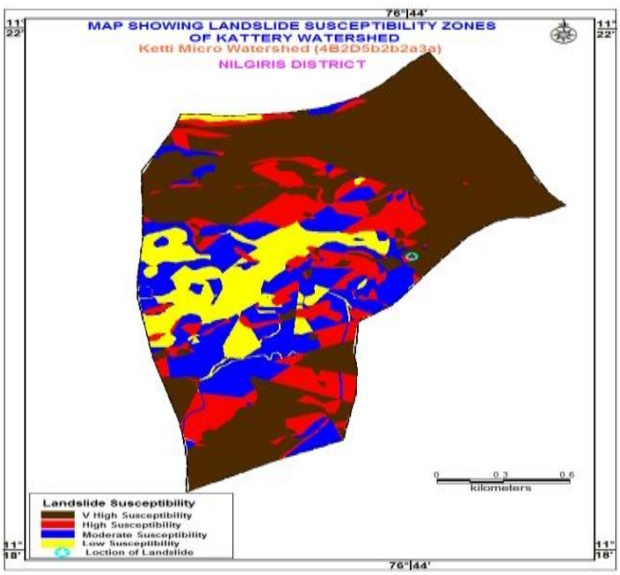

Fig. 3. Kattery Landslide Susceptibility Map

Planning for the possibility of a landslide has been found to benefit from the increased use of PC-based technologies. One of these important tools is Geographic Information Systems (GIS) (GIS). With the aid of GIS, it is possible to combine considered data from a number of levels to understand that boundaries indicate for landslide rate. Since the middle of the 1970s, numerous studies have worked to assess landslide risks and produce hazard maps that depict their geographical distribution using a variety of GIS-based techniques. The results of the papers that were discovered indicate a landslide. Hazard maps have been shown to be extremely valuable tools by planners and managers. Most efforts start by analysing the size and force of landslides to prevent short-term recurrence of slope failures.

The term "Landslide Susceptibility Assessments" is used to refer to such precise evaluation of landslide risk. The subsequent parameters in the Ketti Little Watershed were important for this evaluation of landslide vulnerability to describe the Gradient, Slope, Drainage, Infiltration capacity, Geomorphology, and Lithomarge.

2.2 Preparation of Laboratory Landslide Model (LLM)

Field research was carried out in the Ketti micro watershed to support the thematic maps and collect soil samples for the creation of a lab model. An Abney's level and a clinometer were used to determine the slope's percentage on the location. Previous landslides and landslide imprints were examined on the ground. For engineering quality testing, soil samples from the landslide-prone area were collected and taken to the laboratory. On the landslide-prone location, the zones shown in Table 2 were designated using GPS technology.

Table 2. Detailing of Katteri Watershed

Location	Latitude 11º23′3″ N and Longitude 76º44′0″ E.
Slope	45% to 63%
Altitude	2150 MSL
Depth of lithomarge	6.1 to 8.5m
Soil texture	Sandy clay loam
Land use	Cultivable land
Rainfall	Northeast and Southwest
Aspect	Facing South
Angle of Repose	31º
Drainage Density	Low

A lab model was developed using tests obtained from the examination site because it was difficult to complete the entire research in the field to understand the frequency of landslides at various slopes and soil penetration levels (Figure 4 as well as 5). There have been a several observed slope failures during or immediately after precipitation. Although a rapid increase in pore-water pressure caused by water intrusion has been cited as the cause of these failures, the primary parameters that determine the start of slope failures are still not precisely established. To set up the preliminary interaction of rainfall slope failures to consider such limitations, a series of research centre investigations were conducted on model sandy steep slopes. Analyses of artificial rain falling on top of the slope resulted in failures in limited range model slopes.

Table 3. Laboratory landslide model [LLM]

Description	LLM 1	LLM 2	LLM 3
Slope of the model	30%	53% – 60%	53% – 60%
Soil thickness	Standard [20cm – 30cm]		
Rainfall	Constant	Nil	Constant

Fig 4(a). Before Landslide Stimulation **4(b).** After Landslide Stimulation

Fig. 5. Landslide simulation before (a) and after (b) the event in soil with sensors

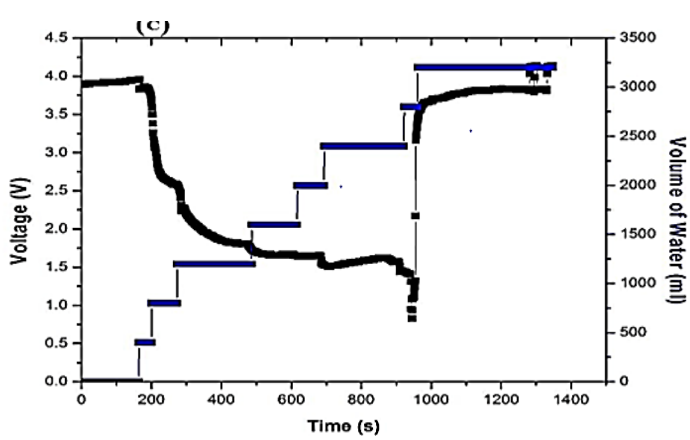

Fig. 6. Graph signifying the effect of water content causing landslide w.r.to time in seconds.

3 Soil Moisture Sensors (SMS)

Soil moisture sensors (SMS) assess the volumetric moisture content of the soil. SMS measure the volumetric water content of the soil indirectly by using another characteristic of the soil as a hold for the moisture content, such as electrical resistance, the material constant, or electron interaction. Direct hydrometric measurement of free-soil wetness requires the removal, drying, and weighting of a sample. According to environmental factors like soil type, temperatures, and electrical conductivity, the relation between both the measured property and soil moisture should be graduated and changed. Mirrored microwave radiation is affected by soil moisture and is used in geophysics and agriculture for sensing. Farmers and gardeners will make use of portable probing tools. Sensors that assess volumetrically water content are frequently consulted by soil moisture sensors. Another type of sensor that measures moisture in soils is water potential; these sensors are commonly referred to as soil water potential sensors and include tensiometers and mineral blocks as shown in Figure.6.

Figure 7. Soil Moisture Sensors

3.1 Laboratory Modelling with Landslide Alert Systems (LAS)

It was discovered during this experiment that after a period of continuous rainfall, the soil became saturated due to infiltration and a rise in pore pressure. At this point, the sensors were activated, triggering the alarm, and there was also slope failure and sub-soil movement because of the soil's decreased shear strength and increased shear stress as mentioned in Figure 5 and 6 and Table 4.

3.2 Natural Disaster Management (NDM)

In general, natural disasters in the watershed, such as landslides and soil erosion, are produced by high rainfall acting as an influencing element. Geographical features, agricultural practices, construction activities, and land degradation, among others, all contribute to the watershed's vulnerability to natural disasters. Heavy rainfall in a vulnerable location has resulted in calamities such as landslides and soil erosion.

4 Results and Discussions

The Northern part of the Katteri watershed is clearly sensitive to landslides, according to the landslide susceptibility assessment (LSA). This zone includes the Ketti micro watershed. Site slope stability has been demonstrated to be dangerous. As a result, the need for a laboratory model to research landslide processes has arisen. During, Laboratory landslide Experiment 1 was discovered that there is just topsoil erosion at this slope percentage, i.e. 30 percent slope with continuous moisture input and standard soil thickness. Although there is significant infiltration, the subsoil remains intact. Also from the Laboratory landslide Experiment 2, it was seen at this proportion of slope, i.e. 60%, with standard soil thickness and no moisture input throughout this experiment. There was no movement of the dirt. Either on the surface of the earth or beneath it.

As per the laboratory landslide experiment 3, slope failure was seen at this percentage of slope, i.e. 60%, with standard soil thickness and steady moisture input. As a result, with persistent rainfall at this slope %, there is subsurface displacement. In terms of steep slope and soil thickness, this experiment shows that rainfall causes most landslides.

Landslide = More slope percentage + Thicker the depth of soil + Heavy rainfall

These landslides occur due to soil saturation by rainfall infiltration. Increase in shear stress and decrease in shear strength of the soil tending it to slide. During the Laboratory landslide Experiment 4, the incline of 60%, the standard soil thickness, and the predictable dampness admission from try no. 3 were totally kept up with in this investigation. A dirt dampness sensor was likewise fitted to identify earth immersion. At expanding slant rates with critical precipitation, it is perceived that slant disappointment happens inferable from an increment in shear pressure and a reduction in shear strength of the dirt. Dirt immersion causes earth disappointment, which brings about a few events. The dirt immersion was estimated by sensors in this trial, which set off the ready framework. This place of soil dampness immersion, which prompts slant disappointments, is identified, and set off. This test was fruitful in scrutinizing the ready framework. At the field level, a similar cycle may be improved to a greater size.

5 Conclusions

To estimate the likelihood of a landslide, GIS and remote sensing software were used. The portions of the Ketti micro watershed in the north, north-east, and north-west have inclined slides. Research conducted in the field has confirmed the large soil thicknesses in these locations. To create a reliable landslide vulnerability evaluation map, experts looked at a variety of factors, including slope, present land use, geomorphology, waste, lineament, angle, and soil thickness. The above elements were placed and loaded properly to evaluate the landslide assessment map. A landslide susceptibility map was created after incorporating the maps. The conclusions from this guideline determined the scope of the entire investigation. A lab model of a landslide zone was created to study landslide action at various steep slopes and precipitation levels because most large-scale experiments couldn't be conducted in the field. According to the investigation, if precipitation is the major initiating factor, landslides are likely to occur on more steep slant slopes with more depth soil.

Slope + More soil depth + Heavy rainfall = Landslide

The use of soil moisture sensors as a landslide warning system was successfully implemented in the model. As a result, landslide pre-alert systems could be a useful technique for dealing with natural disasters.

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