LANDSLIDE DISASTER MANAGEMENT PLAN FOR RAJAKUMARY GRAMAPANCHAYATH,IDUKKI DISTRICT

THESIS REPORT

Submitted by

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MUP (2020 - 2022) BATCH

To

the APJ Abdul Kalam Technological University in partial fulfillment

of the requirements for the award of the

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URBAN PLANNING

DEPARTMENT OF ARCHITECTURE

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CERTIFICATE

Certified that the Project entitled **“Landslide Disaster Management Plan for Rajakumary Gramapanchayath, Idukki District”** submitted by **Haridev MJ (TKM20MUP008)** of MUP (2020-22) BATCH, in partial fulfillment of the requirements for the award of Post-Graduate Degree in Urban Planning,under the APJ Abdul Kalam Technological University is a Bonafide work carried out by them under our guidance and supervision.

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It is my privilege to release the feeling of my gratitude to several persons who helped directly or indirectly to complete this thesis work. The success and final outcome of this project required a lot of guidance and assistance from many people and I am extremely fortunate to have got this all along the completion of my thesis. Whatever I have done is only due to such guidance and assistance and I would not forget to thank them.

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ABSTRACT

Landslide is considered one of the most disastrous global hazards which has been occurring more frequently in recent times. Landslide occurrence depends upon geological and geomorphological processes, changes in vegetation cover, landuse and hydrogeologic conditions. Heavy precipitation, earthquakes and human activities increase the chance of landslides. Landslides destroy residential and industrial area and negatively affect water quality in rivers and streams in addition to loss of lifes. Landslide causes damage to the environment, infrastructure, social wellbeing, economic stability, disordered transport and communication facilities, as well as loss of life. Sensitive slopes and the natural flow of streams, quarrying, hydel projects and other developmental activities in the ecologically sensitive areas have added to the disaster.Landslide Disaster management is to be considered futuristically, in which all the appropriate measures during the 3 stages of a disaster needs to be taken effectively and seriously. This Thesis is about making a Disaster Management Plan with impact mapping for Landslide Disaster in Rajakumary Gramapanchayath to support and prepare the inhabitants consisting of around 16000 people for a future Landslide Disaster. The study discusses various community participation ways to approach the scenario futuristically for Landslide Disaster Management.

Keywords: Landslides, Community Participation,Hazard & Impact Mapping.

DECLARATION

I hereby declare that the project entitled **"Landslide Disaster Management Plan for Rajakumary Gramapanchayath, Idukki District"** is a bonafide record of the study done as part of thesis workof under the supervision Dr.Annie John during the **Fourth Semester M.Plan (2022)** Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College Of Engineering, Kollam.I declare that, to the best of my knowledge, the work reported herein does not form part of any other project report or dissertation onthebasis of which a degree or award was conferred on an earlier occasion to any other candidate.

Place: Kollam

Date: 12/09/2022

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ABBREVIATIONS

COVID-19	Coronavirus disease of 2019
UNISDR	United Nations International Strategy for Disaster Reduction
DM	Disaster Management
ESZ	Ecologically Sensitive Zones
NDMA	National Disaster Management Authority
UT	Union Territory
CP	Community Participation
WGEEP	Western Ghats Expert Ecological Panel
SOP	Standared of Operating Procedures
DRR	Disaster Risk Reduction
LSG	Local Self Government
SIC	State Incident Commander
DIC	District Incident Commander
F&RS	Fire & Rescue Station
GSI	Geographical Survey of India
LHZ	Landslide Hazard Zonation
DMS	Disaster Management Support

CHAPTER 1
INTRODUCTION

This chapter explains the background and need for the study. The methodology adopted for the research and the study's scope and limitations are mentioned here. The study's aim and objectives are also listed in this chapter.

1.1 BACKGROUND TO THE STUDY

There have been many deaths and significant damage due to landslides in India, including damage to communication routes, human settlements, agricultural fields, and forest lands. A wide range of landslides occurs in India, causing significant destruction in terms of lives and property.In our country, landslides occur on an area of 0.42 million hectares, or approximately 12.6% of the total land area.The mountainous region of the North-Western Himalayas, the Sub-Himalayan terrain of the North-East, and the **Western and Eastern Ghats** are prone to landslides covering 22 States and 2 Union Territories.

Spanning India's western coast, the Western Ghats extend from the Vindhya-Satpura range in the north to the southern tip in the south. Various vegetation can be found in the Western Ghats, including scrub jungles, deciduous forests, semi-evergreen forests and grasslands at lower elevations. In Kerala, the Idukki district holds the highest peak at 8841 feet.

Monsoon systems are best illustrated at this site. Additionally, it is considered one of the world's eight 'hottest hotspots' for biological diversity due to its exceptional biological diversity and endemism.

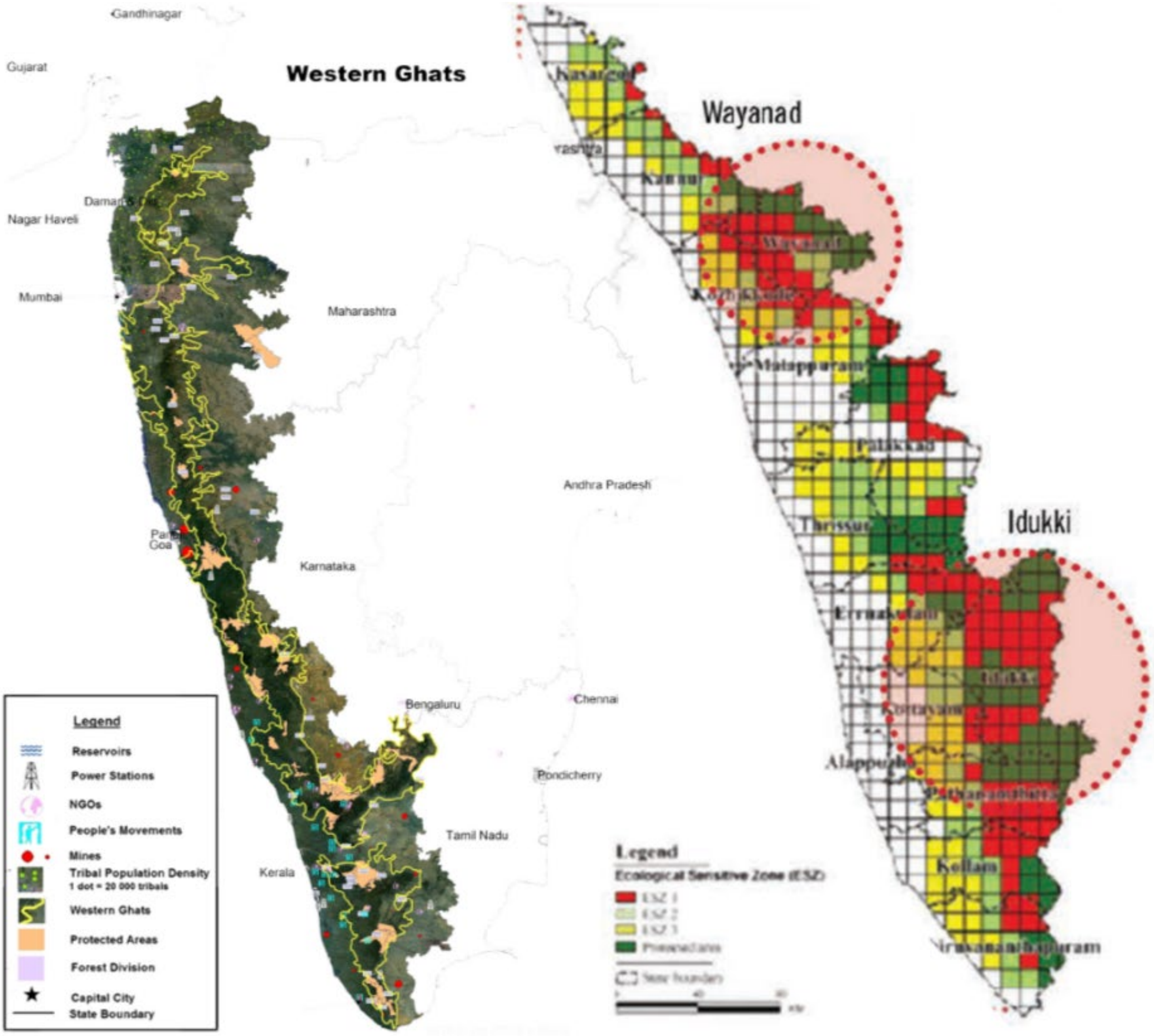

Figure 1.1 – Ecologically Sensitive areas of Western Ghats

Source: WGEEP 2012

1.2 NEED FOR THE STUDY

The Western Ghats is considered an ecologically sensitive region with nearly 52 species moving one step closer to extinction. A total of 325 critically endangered species are found in the Western Ghats, according to the IUCN Red Data List. Two hundred twenty-nine plant species, 43 amphibian species, 15 bird species, 31 mammal species, five reptile species, and one fish species are part of the Western Ghats' globally threatened flora and fauna. According to estimates, 325 species live in the Western Ghats, 129 are vulnerable, 145 are threatened, and 51 are critically endangered.

As the Western Ghats region has become increasingly urbanised for commercial and economic reasons, flora and fauna habitats have been drastically altered.Degradation of natural resources occurs due to railroad development and hydroelectric power development.

1.3 IMPORTNCE OF WESTERN GHATS

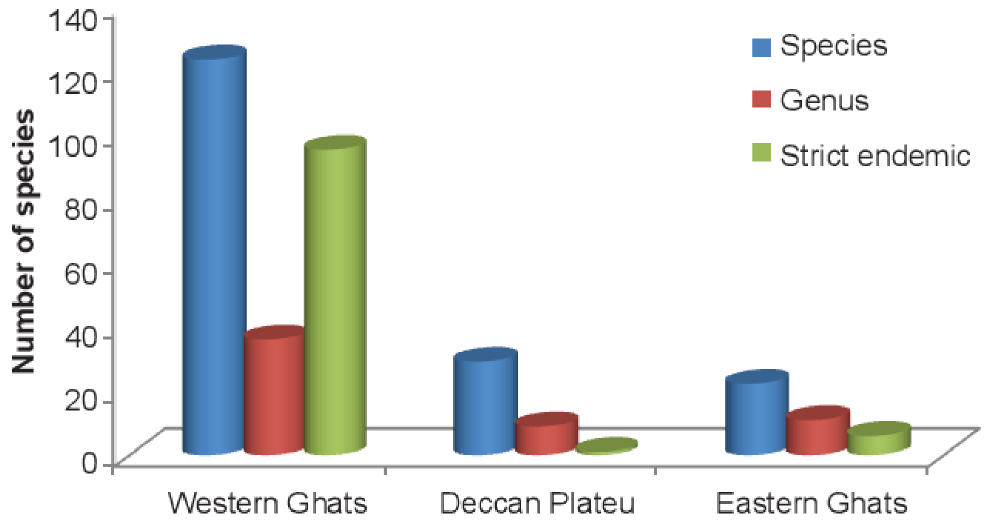

Figure 1.2 – Endemism In Species of Western Ghats
Source: WGEEP

During the monsoon season (South West and North East monsoons), the Western Ghats running along Kerala's length undergo frequent landslides. In the Western Ghats, 8% of the area has been identified as a landslide hazard. Kerala endured the worst floods since 1924 between 1 June and 18 August 2018. The state saw cumulative rainfall that was 42% over average during this time.Floods were aggravated by torrential rainfall and the release of excess water from 37 dams across the state, which triggered several landslides. It has been reported that nearly 341 landslides have occurred in 10 districts. One hundred forty-three landslides ravaged Idukki, one of the worst-hit districts. Floods and landslides affected at least 5.4 million people, caused 1.4 million displacements and caused 433 deaths.(Landslide susceptibility investigation for Idukki district,2019).

The exploitation of Western Ghats and its Impacts

Landslides are a significant cause of death and property damage in India, resulting in a substantial loss of life and property. Many deaths are associated with landslides in India and harm to human settlements, agricultural fields, and forest lands.According to the Kerala State Disaster Management Authority (KSDMA), 46.93% of landslides reported in Kerala during 2018 had occurred in the Idukki district.

4642 (98.18%) landslides occurred in the Western Ghats region, where 3903 (84.08%) fall within Western Ghats's Environmentally Sensitive Area (ESA). These landslides and floods resulted in the death of 483 persons and large-scale property loss.

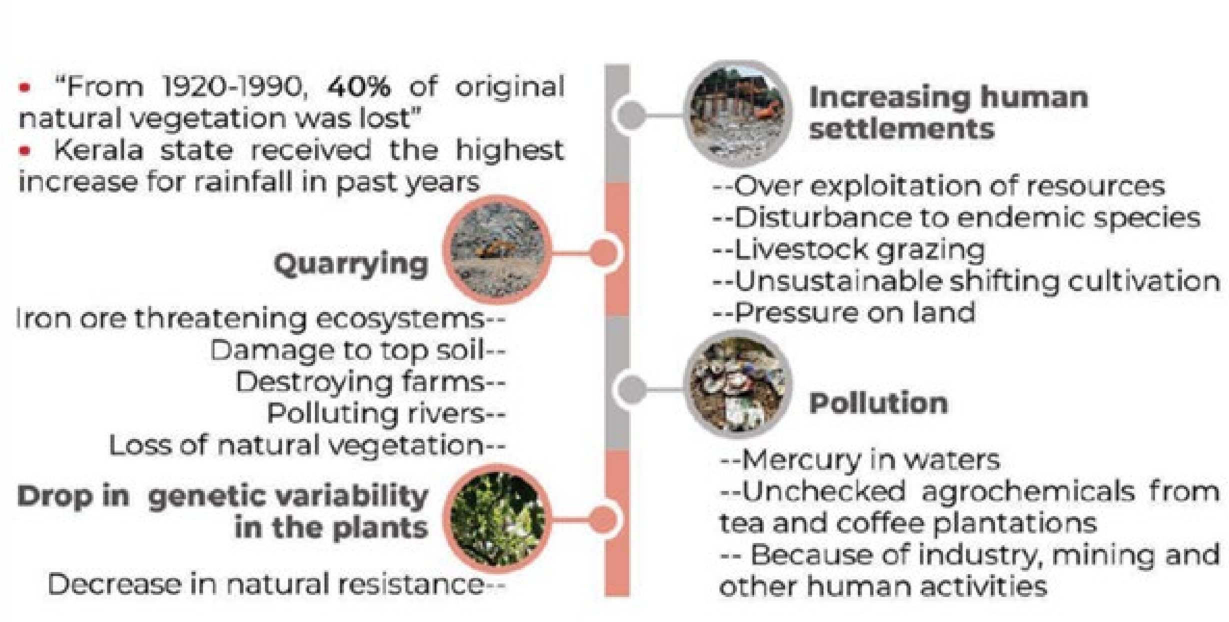

Figure 1.3 – Threats to the Western Ghats

Source: Western Ghats biodiversity hotspots in danger, GnY, 2016

Landslide in Pettimudi,Idukki.

A disastrous landslide occurred in the Pettimudi village of Idukki (D'Acunzi, 2019) district, Kerala State, at 22:45 h on 6 August 2020 due to heavy downpours. The disaster caused 70 fatalities and more than 1700 schools in the state and caused them to serve as relief camps.Most of the camps closed after ten days. Floods affected teaching and learning in almost all the districts, with institutions being closed from 2 to 23 days. Students also could not attend school due to trauma and stress because of loss of family/friends and large-scale damage to their homes or neighbourhoods.

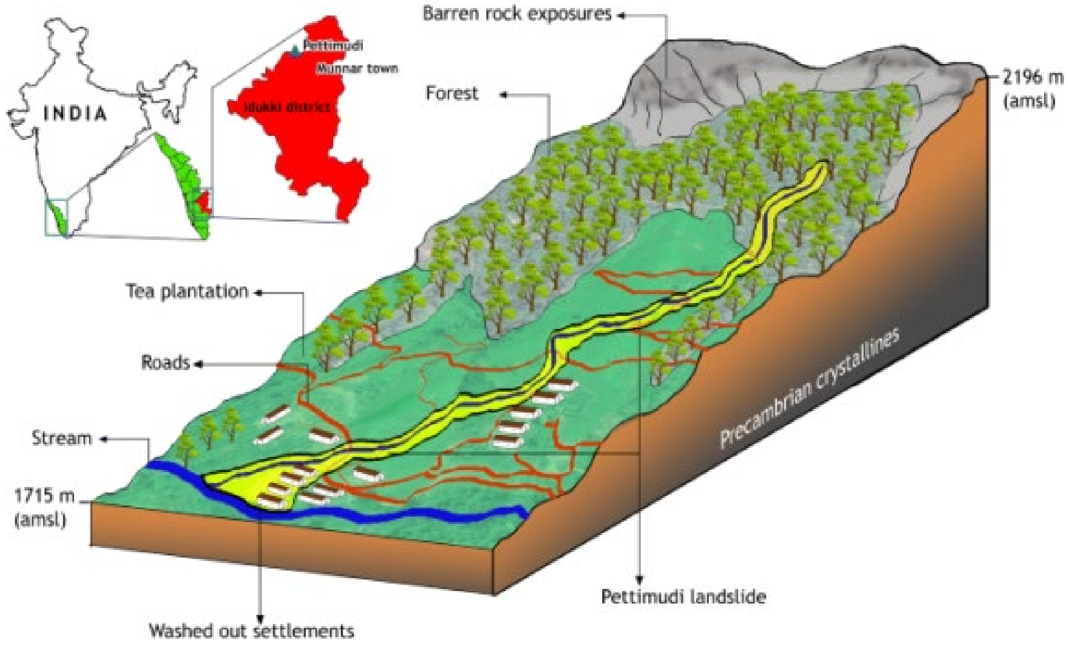

Figure 1.4 –Pettimudi landslide,Idukki,Kerala

Source: The New Indian Express ,2018

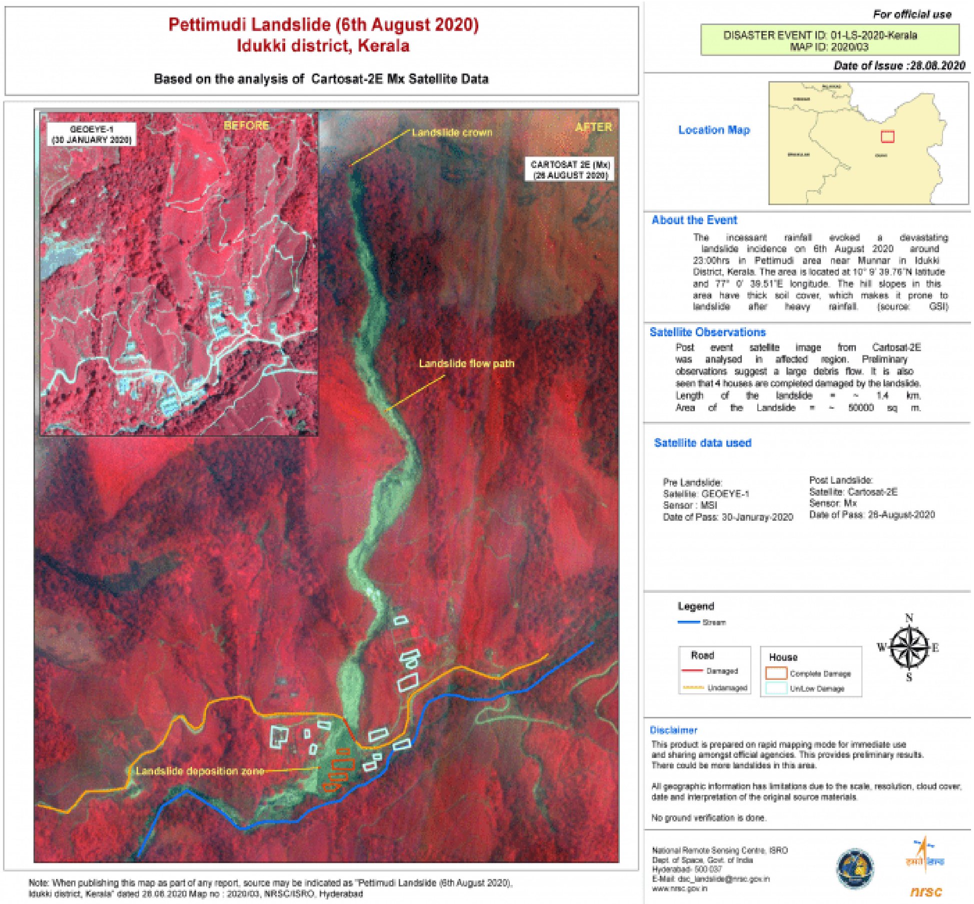

Figure 1.5 – Pettimudi Landslide Disaster(8th,August2020)Idukki,Kerala

Source: The New Indian Express

1.4 RECOMMENDATIONS OF VARIOUS COMMITTEES

RECOMMENDATIONS OF GADGIL COMMITTEE-WGEEP 2012 are

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.

RECOMMENDATIONS – KASTOORIRANGAN COMMITTEE WGEEP 2013

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

However, the structure we have in place today forcibly separates growth from conservation. It ultimately results in a paradox where our policies encourage careless growth in specific regions and wild protection in others. (Gadgil Report -part 1)

1.5 OBJECTIVE

This study is performed to prepare Landslide disaster management for Rajakumary Grama panchayath, Idukki.

1.6 OBJECTIVES

- ❖ To identify the types of Landslides occurring in Idukki, their causes and impacts.
- ❖ To develop a methodology for identifying the study area.
- ❖ To conduct literature-based risk assessments and vulnerability mapping.
- ❖ To identify and examine various parameters associated with Evacuation mapping and preparation.
- ❖ To formulate inclusive planning strategies for preparing a landslide disaster management plan for Rajakumary Grama Panchayath.

1.7 RESEARCH METHODOLOGY

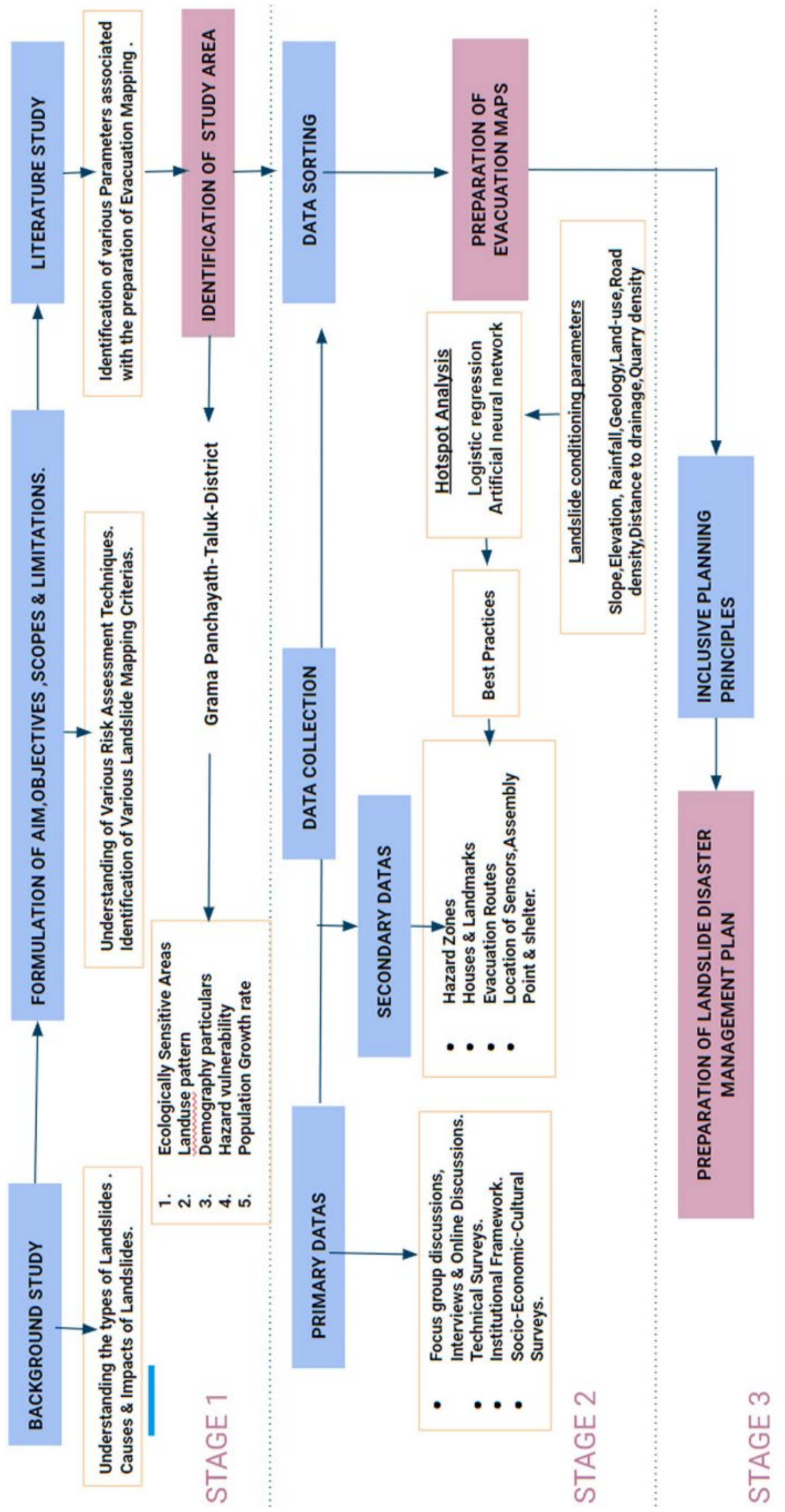

Figure 1.6 – Methodology for the study

1.8 SCOPE

- ❖ The study discusses the various Landslide disasters in the Kerala context, their socio-economic and cultural causes and their impacts.
- ❖ The study discusses the various inclusive planning methods for active community participation during adversity.
- ❖ The study determines the most suitable method for preparing a Landslide disaster management plan.

1.9 LIMITATIONS

- ❖ The study focuses only on preparing a management plan for landslide disaster, not for its commonly associated disaster - Flood.
- ❖ Inclusive planning strategies and criteria obtained from best practices across nations are site/location specific and are less feasible for the Kerala context.
- ❖ The disaster management plan preparation study is only limited to Rajakumary Grama Panchayath, and all other Landslide-prone areas are intentionally omitted.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses landslides, types of landslides and landslide zoning. Disaster Management Authorities, NGOs And Stakeholders' roles in preparing Landslide disaster management plans are also explained. The Literature study also focuses on the Impacts Of the 2018 Landslides in Idukki.

2.1 INTRODUCTION

In general, landslides result fromthe downward movement of soil, rock, and organic materials related to gravity, and they also refer to the landforms resulting from these movements. (Highland, 2008)Every year, millions of deaths and injuries are caused by landslides worldwide, under all climatic conditions and terrains.Natural disasters often disrupt the economy, displace populations, and negatively impact the Environment over the long term.

Landslide-prone areas may not be adequately planned for when land-use policies are outdated.There are multiple reasons for low or nonexistent land-use policies that moderate perceptions of and actual damage from geologic hazards. Intricacies and complexities of community political, cultural, and financial structures contribute to poor or nonexistent land-use policies that minimise geologic hazards' perceived or actual danger.Landslides frequently are characterised as neighbourhood problems. However, their outcomes and costs regularly go neighbourhood jurisdictions and might be State, Provincial or country-wide problems.

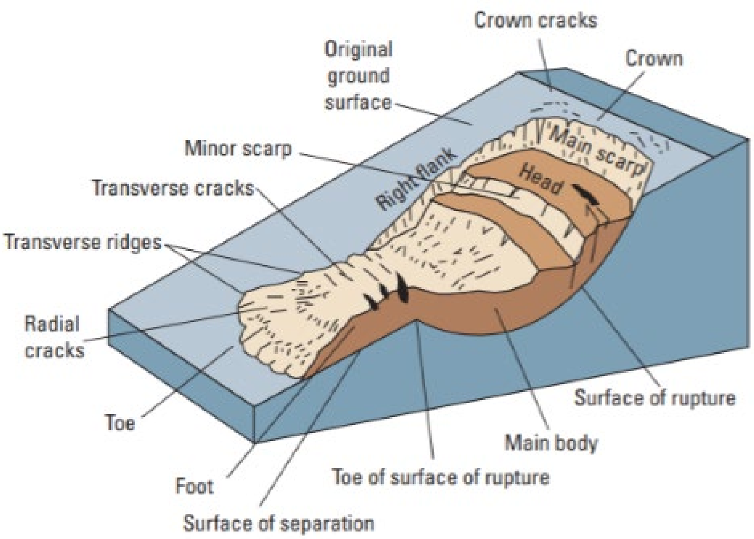

Figure 2.1 **A simple illustration of a landslide**

2.2 TYPES OF LANDSLIDES

The type of landslide will decide the potential speed of movement, expected displacement volume, run-out distance, the possible repercussions of the landslide and the relevant mitigating actions to be taken. The landslide mass is shifted internally depending on the movement type—fall, topple, slide, spread, or flow.

2.2.1 Fall

When soil or rock, or both, separate from a steep slope along a surface where there has been little to no shear displacement, a fall is said to have begun, the debris then mainly falls, bounces, or rolls as it descends.Individual pebbles or dirt clumps to large boulders of hundreds of cubic metres can make up a significant portion of the debris in a fall.

Triggering mechanism -Slope undercutting caused by human activities like excavation during road building and maintenance, earthquake shaking, or other extreme vibration. Natural processes include rivers and streams, differential weathering (such as the freeze/thaw cycle), and undercutting slopes by differential weathering.

Effects - There is a risk of death from falling debris. The vast boulders' property below the fall line may sustain damage from falls. Boulders can roll or bounce large distances, destroy buildings, and kill people. Rockfalls can cause deaths in cars hit by rocks and block highways and rails, resulting in extremely high levels of road damage and railroads.

Corrective measures/mitigation -The use of explosive blasting to remove the source from dangerous target locations, rock curtains or other slope coverings, protective covers over roadways, retaining walls to stop rolling or bouncing, and the removal of boulders or other debris off highways and trains are all possible. Scaling cliffs and using rock bolts or similar anchoring techniques might decrease the danger. It should be prohibited to stop or park underneath dangerous cliffs. For public awareness, warning signs are advised in unstable regions.

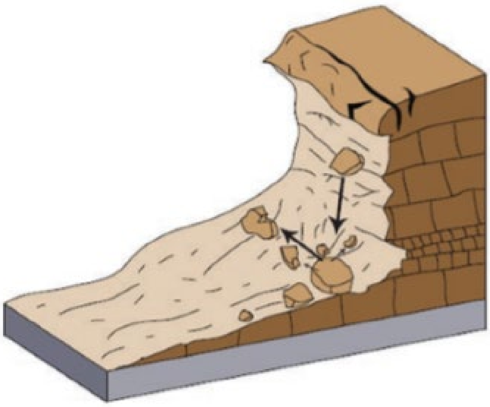

Figure 2.2 Schematic diagram of a Rockfall

Figure 2.3 rockfall /slide clear at Creek Canyon, Colorado, USA, in 2005

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2.2.2 Topple

The term "topple" refers to the forward movement of a mass of soil or rock out of a slope around a point lower than the centre of gravity of the displaced material. The weight of the material upslope from the shifted mass might occasionally exert gravity to cause toppling. Water or ice that has gotten into the mass's fissures has sometimes caused toppling.

Triggering mechanism - Water or ice that forms in fissures inside the displaced mass can also cause displacement. Other factors that can cause removal include vibration, undercutting, differential weathering, excavation, and stream erosion.

Effects (direct/indirect) - Can be highly destructive, especially when failure is sudden and (or) the velocity is rapid.

Corrective measures/mitigation - There are several ways to stabilise regions prone to toppling in rock. Rock bolts, mechanical anchors, and various sorts of anchors are a few of these slopes' strengthening techniques. Drainage needs to be taken into consideration and rectified as a corrective measure since seepage is another aspect that contributes to rock instability.

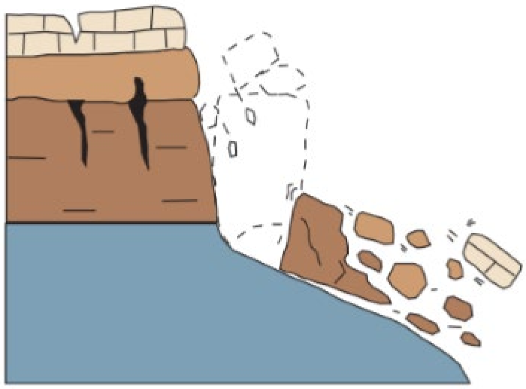

Figure 2.4 Schematic sketch of a Topple

Figure 2.5 A Topple at Fort St. John, British Columbia, Canada,2007

2.2.3 Slides

A slide is a downward movement of a soil or rock mass that occurs on ruptured surfaces or narrow zones of severe shear strain. The volume of the displaced material expands from a localised point of failure; the movement does not initially begin concurrently throughout what ultimately becomes the surface of rupture. The ejected material's upper surface may lean rearward toward the scarp, and its head may slide virtually vertically downward. A slump is a slide that rotates and has several parallelsand curved lines of motion.

Triggering mechanism - Intense and (or) continuous rainfall or quick melting can cause slopes to become saturated, raising groundwater levels inside the mass. Rapid river level dips after floods can also promote erosion at the base of slopes, increasing groundwater levels brought on by filling reservoirs. Earthquakes can also bring on slides of this nature.

Effects (direct/indirect) - These May be exceedingly harmful to buildings, roads, and lifelines yet, if movement is gradual, are often not life-threatening. The mass's tilting and deformation can cause severe damage to structures on it as well. It is challenging to fix the significant amount of material displaced permanently. These mistakes can make dam rivers, which leads to floods.

Mitigation measures - It is possible to deploy instrumented monitoring to find movement and measure movement speed. Although well-built retaining walls near the toe may help slow or deflect the moving earth, the slide may still topple such barriers. Drainage paths that have been obstructed must be repaired or redesigned to avoid further water accumulation in the slide mass. Wherever feasible, proper slope engineering and grading will significantly lessen the risk.

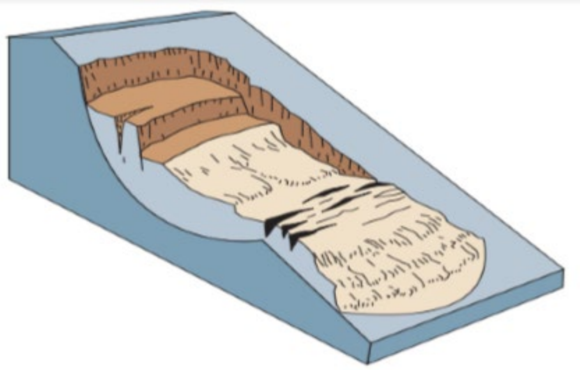

Figure 2.6 Schematic sketch of a Rotational Landslide

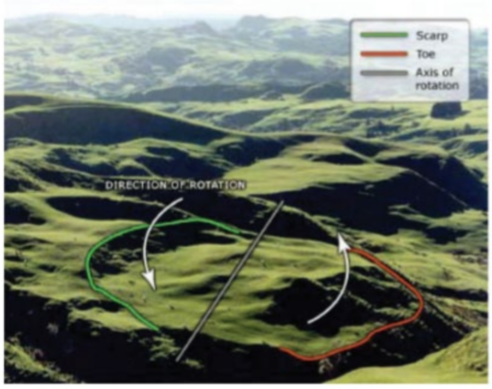

Figure 2.7 A Landslide occurred at Newzealand (21 September 2007).

2.2.4 Translational Landslide

With minimal rotating movement or rearward tilting, the mass of a translational landslide flows outward, or down and outward, down a surface that is mainly flat. Contrary to rotational slides, which tend to bring the slide equilibrium back, this slide can advance across significant distances provided the rupture surface is sufficiently sloped among the landslides that occur most frequently everywhere. They may be found anywhere in a variety of situations and habitats.

Triggering mechanism - The leading causes of slides include heavy rain, snowmelt, floods, or other inundations of water brought on by irrigation, leaks from pipelines and human-caused disturbances like undercutting. An earthquake could bring on these landslides.

Effects (direct/indirect) - Translational slides may begin slowly, causing damage to assets and lifelines; nevertheless, under extreme circumstances, they may pick up the pace and pose a hazard to life. They may dam rivers, which would result in floods.

Mitigation measures-To avoid sliding or, in the event of an existing breakdown, adequate drainage is required to stop the movement from reactivating. The remedial procedures are levelling, appropriate grading and drainage, and retaining walls. Anchors, bolts, and dowels are more complicated rock cures that specialists should only use in all conditions. It is challenging to permanently stabilise translational slides on slopes with a moderate to steep gradient.

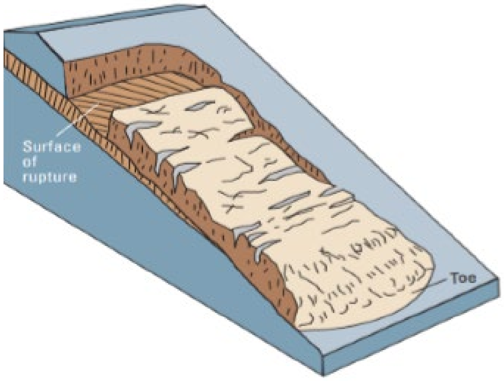

Figure 2.8 Schematic sketch of a Translational Landslide Figure 2.9 A Landslide at Beatton River Valley, Canada.2001

2.2.5 Spreads

A cohesive rock or soil mass expands along with a general sinking of the shattered cohesive group into the less sturdy underlayer. Spreads can happen when the softer underlying material flows or liquefies (and extrudes).Block spreads, liquefaction spreads, and lateral spreads are a few different types.

Triggering mechanism- Triggers that destabilise the weak layer include:

• Liquefaction of lower weak layer by earthquake shaking

• Natural or anthropogenic overloading of the ground above an unstable slope

• Saturation of the underlying weaker layer due to precipitation, snowmelt, and (or) groundwater changes

• Liquefaction of underlying sensitive marine clay following an erosional disturbance at the base of a riverbank/slope

• Plastic deformation of unstable material at depth (for example, salt)

Effects (direct/indirect) - Can cause extensive property damage to buildings, roads, railroads, and lifelines. Lateral spreads may be a precursor to earth flows. It can spread slowly or quickly, depending on the extent of water saturation of the various soil layers.

Mitigation measures - Liquefaction-potential maps exist for some places but are not widely available. Areas with potentially liquefiable soils can be avoided as construction sites, particularly in regions that experience frequent earthquakes. If high groundwater levels are involved, places can be drained, or other water-diversion efforts can be added.

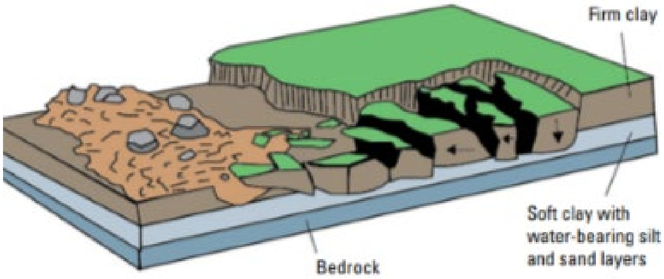

Figure 2.10 Schematic of a Lateral Spread **Figure 2.11 Lateral spread at in,California, USA,1981**
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2.2.6 Interrelationship of Landslides with Other Natural hazards — The Multiple Hazard Effect.

Natural disasters, including landslides, earthquakes, volcanic eruptions, and floods, can co-occur or be triggered by one or more disasters (Highland, 2008). If a dam fails, the impounded water will be suddenly unleashed to cause flooding downstream.

This flooding can then add to the riverbank and coastal erosion and destabilisation through rapid saturation of slopes and undercutting of cliffs and banks. When evaluating an area's vulnerability to landslides, it is imperative to examine all other possible natural hazards.

2.3 LANDSLIDE ZONING

Landslide Zoning divides hill or mountainous areas into homogeneous spatial areas/slopes according to their degrees of actual or potential **landslide susceptibility**, **hazard** or **risk.**

Landslide Susceptibility Zoning -uses an inventory of past landslide incidences together with an assessment or prediction of the spatial areas/ slope with a likelihood of landslides in the future. Susceptibility zoning thus involves the spatial distribution and rating of the terrain units according to their propensity to produce landslides. This depends on the topography, geology, geotechnical properties, climate, vegetation and anthropogenic factors such as the development and clearing of vegetation.

Landslide Hazard Zoning- uses the landslide susceptibility maps and assigns an estimated frequency (i.e. annual probability) to the potential landslides of a certain magnitude. It should consider all landslide events that can affect the study area, including landslides above the study area that may travel onto it and landslides below the study area which may retrograde up-slope into it.

Landslide Risk Zoning - depends on the elements at risk, their temporal-spatial probability (or exposure) and vulnerability and is the ultimate aim of any zoning exercise. For areas with existing development, it should be recognised that risks may change with additional development; thus, risk maps should be updated regularly.

A **landslide early-warning system** (LEWS) is envisaged as a system capable of modelling landslide occurrences and providing timely warning about the impending danger. It can be of different types, depending on the type of landslides, the target warning area and the communities being warned.

All the above zoning activities aim to comprehensively manage the landslide risk in fragile hilly and mountainous areas, reducing losses due to landslide hazards. Therefore, landslide zoning is always to be construed and viewed as an integral part of the broader landslide risk management framework. (Fell et al., 2005).

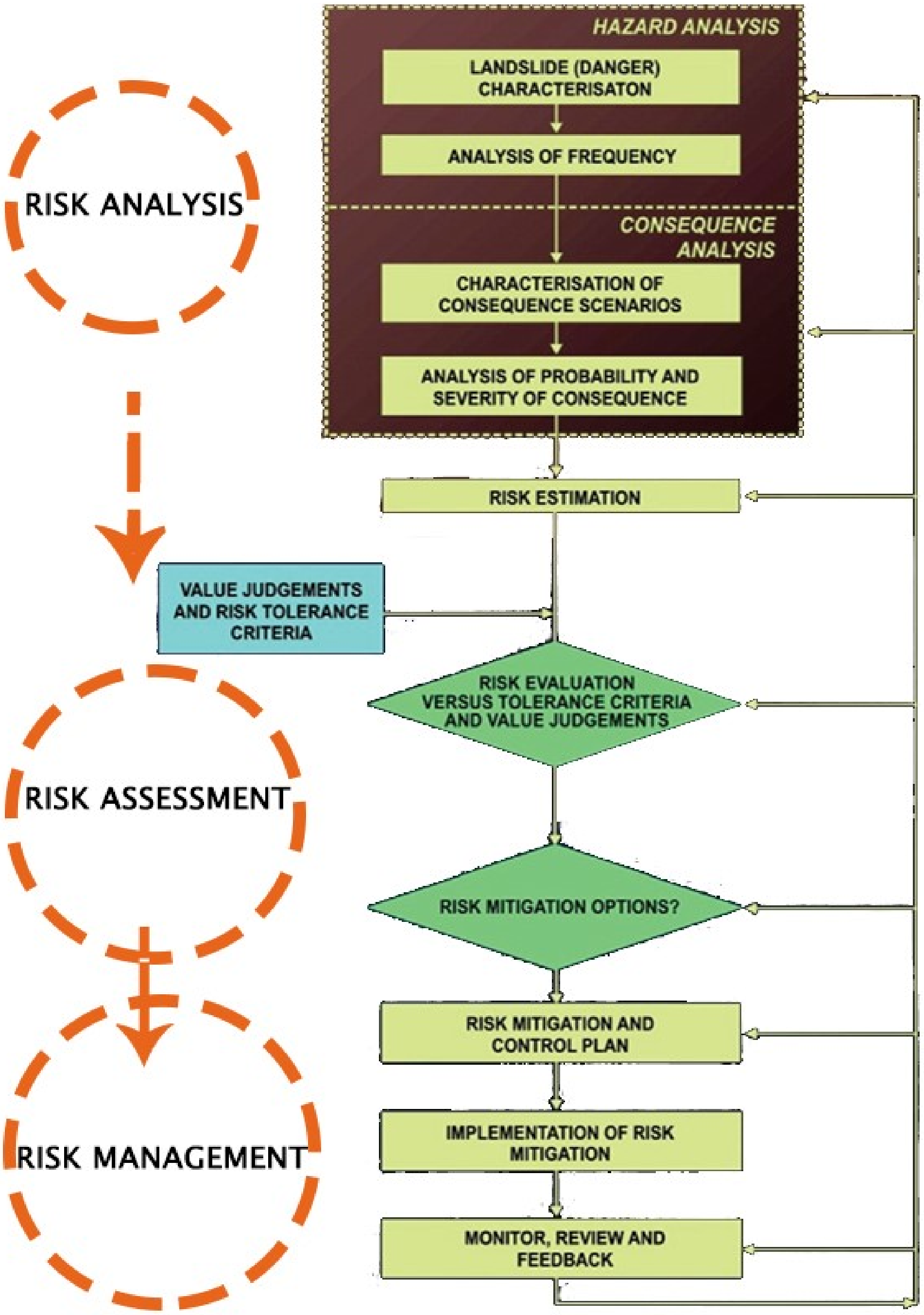


Figure 2.12 Landslide Risk Management Framework (Fell et al., 2005)
Source: UNISDR ,2005

2.4 UNISDR ELEMENTS OF INCLUSIVENESS

A new standard with seven sub-systems for landslide early warning is proposed by the UN International International Disaster Reduction Strategy. These include risk assessment and mapping, dissemination and communication, establishing the disaster preparedness and response team, developing an evacuation map, standardising operating procedures, Installing monitoring and warning services, and building local commitment to the operation and maintenance of the entire program.

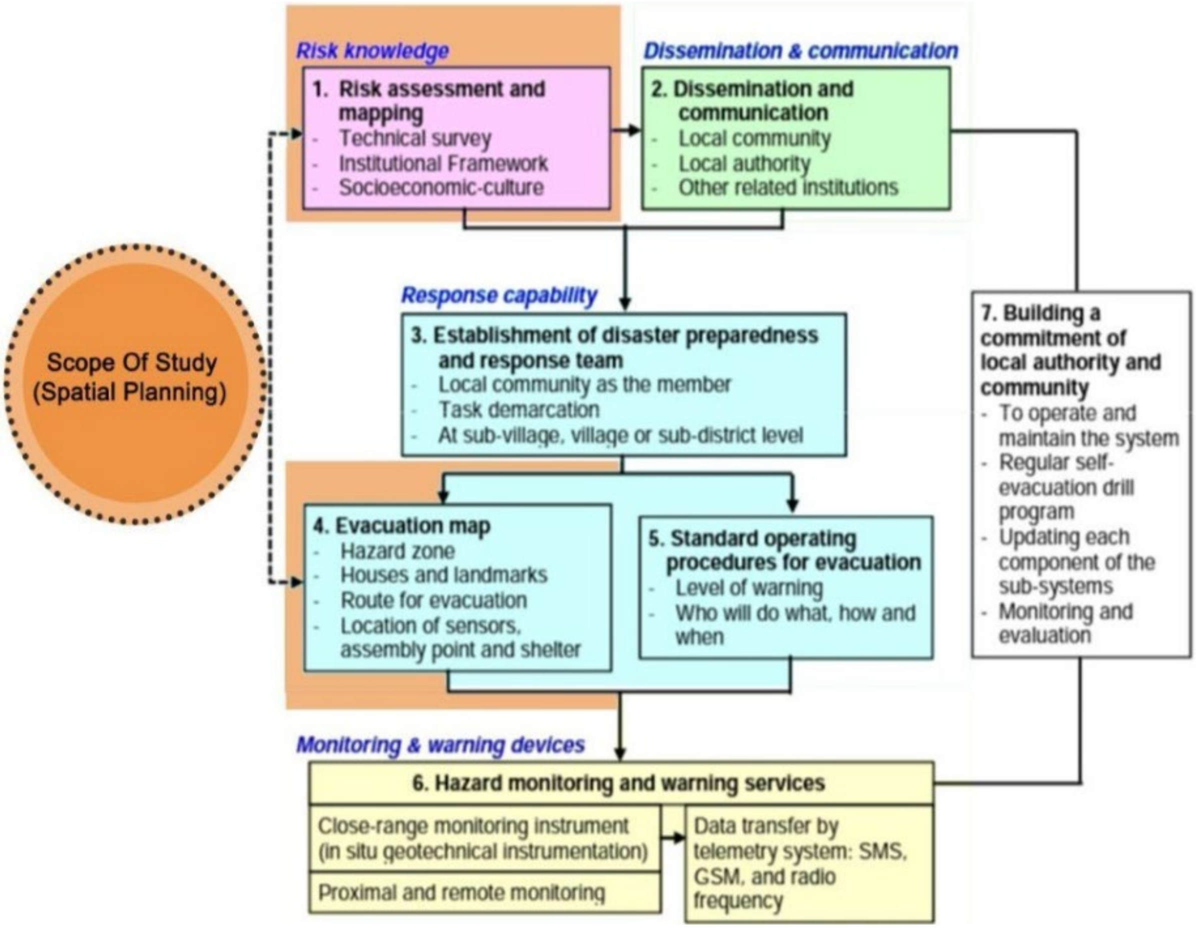


Figure 2.13 United Nations International Strategy for Disaster Reduction -Elements Of Inclusiveness

Source: UNISDR ,2005

Landslides are often triggered by intense rainfall or earthquakes, and it is observed that seismic high-hazard zones and high rainfall areas coincide with high landslide hazard zones. Therefore, for early warning of landslides in India, it is pertinent to explore both the triggering factors, i.e. precipitation and seismicity.

2.4.1 Risk Assessment and Mapping.

Risk assessment and mapping are carried out by technical, institutional, and socio-economic–cultural surveys within the vulnerable Community.This systematic methodology helps to

define the dangerous and safe areas and prioritises where to install hazard monitoring and alerting equipment.
The technical survey is carried out to comprehend the geological conditions in specific locations, mainly to identify stable zones and places susceptible to landslides. This survey is also being done to learn more about past landslide movements, damaged infrastructures, and indications of a mass movement, including cracks, subsidence, spring water appearing, fractures in structures, and tilting of poles and trees. You can choose where to put the tools for early detection and monitoring landslides.

- The **institutional survey** is performed to understand whether an established institution or a local organisation exists to monitor and mitigate landslide hazards.
- To determine socially acceptable entry points for the collaborative deployment of an early warning system, a **cultural-economic survey** is done to gather data on community demographics, including population (household), age, education, financial status (car and cattle ownership), and culture.
- The purpose of the **social survey** is to identify social concerns and gaps in the Community and to ascertain how well the Community understands landslide threats. To control the risk reduction method appropriate for the local socioeconomic-cultural circumstances, the Community must be eager and motivated to engage actively.
- The Important Data to be Collected on Socio-Economic Survey includes the number of households. Vulnerable groupsand number of vehicles.

2.4.2 Dissemination and communication

The goal of information dissemination on landslide catastrophes is to help people comprehend and understand the community and its goals. The purpose of distribution is to increase public awareness of landslide features that endanger their region (such as causes and processes) and ways to reduce risk.Additionally, it would be able to identify the crucial individuals who are strongly committed to serving as forerunners in the development of the disaster preparation team throughout the dissemination and communication process.

2.4.3 Formation of a catastrophe preparedness and response team

Local governments or associated organisations promote community consultation to build a disaster preparedness and response team. This team's appointment is based on each member's ability in landslide preparedness, prevention, mitigation, emergency response, and post-disaster management.

Safe escape routes and planned assembly spots should be included on an evacuation map detailing the risky areas and places safe from landslide danger (assembly points). The disaster planning and response team creates the map after receiving a briefing on hazard mapping.

2.4.4 Conception of an evacuation map

Safe escape routes and deliberate assembly spots should be included on an evacuation map that details the risky areas and regions free from landslide danger (assembly points). The landslide risk zones and evacuation routes provide operational directions for the disaster preparedness and response team and the vulnerable Community, instructing them to assemble at a designated location and then evacuate along a preset path.

An evacuation map should provide information on,

a. Zones of high- and low-risk (safety).

b. Characteristics of a landslide: the crown, fractures, movement direction, landslide border, and springs.

c. Residences and significant buildings, including offices, landmarks, a community health centre, a school, a mosque, and a church.

d. Alert post, assembly point(s), and refuge in case of emergency(s).

e. The location where the early warning system is installed.

f. Alleys and streets.

g. The evacuation path(s).

2.4.5. Standard operating procedures development

When dealing with all danger levels, the standard operating procedures (SOPs) serve as a guide for the Community living in a hazard-prone region and the disaster preparedness team.

The Community's and local government's dedication is essential for the system's operation and upkeep so that all of the activity phases listed in the SOPs proceed smoothly.

2.4.6. Installation of hazard monitoring and warning services and implementation of the evacuation drill.

The traditional monitoring systems include several sensors to detect ground movement, groundwater level fluctuations, porewater pressure, and rainfall (rain gauge, extendometer, tiltmeter, inclinometer, and pipe strain gauge) (piezometer). Each monitoring gadget transmits specific information about the degree of danger to the neighbourhood and the nearby control centre.

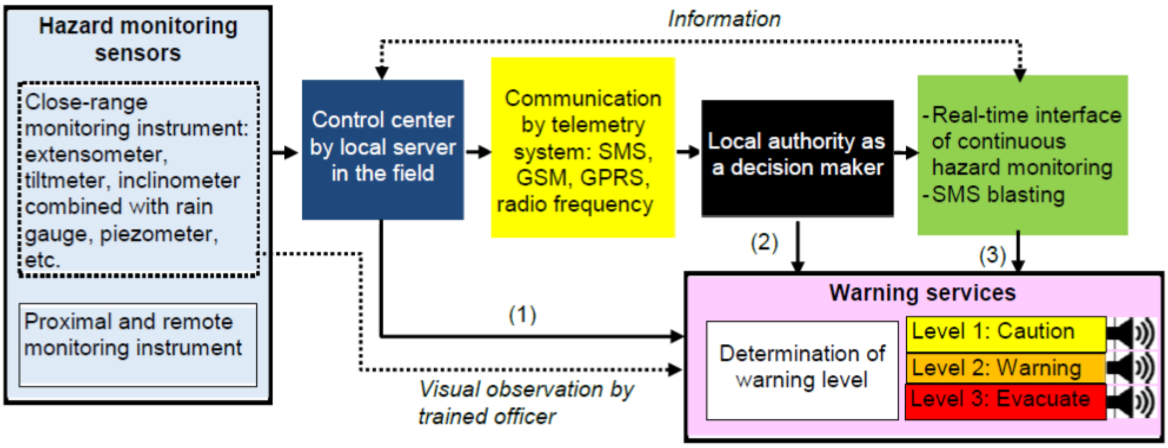


Figure 2.14 Mechanism of data transmission among landslide monitoring and warning devices.
Source: UNISDR ,2005

2.4.7 Commitment of the local authority and Community

When responding to particular landslide alarms, it is crucial to create SOPs that identify the roles and duties of the Community and the disaster preparedness team. Each level's local authority is responsible for receiving reports from the team leader, inspecting the scene, and offering emergency assistance to the evacuated population. (Michoud et al., 2013).

The Community's and local government's dedication is essential for the system's operation and upkeep so that all of the activity phases listed in the SOPs proceed smoothly. (Fathani, 2016)

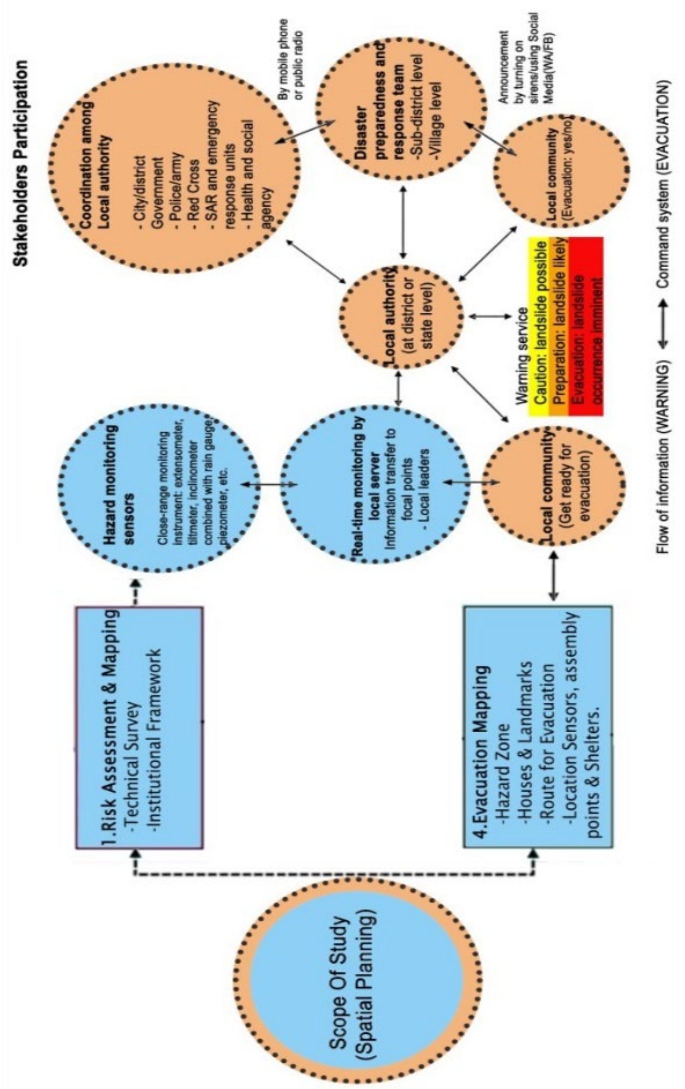


Figure 2.15 Framework for Disaster Management Plans for a Landslide-prone area involving Community

Source: **Author generated**

The Framework identifies the Scope of the Study on the Spatial elements like Preparation of Mapping,especially on the Risk Assessment and Evacuation mapping of UNISDR,that is, on the calculation of Risk Assessment & Mapping through Technical survey as well as through Institutional Frameworks.Spatial Planning aspects are more concentrated on the fourth element of UNISDR,which is preparing Evacuation Mapping that includes Hazard Zones,Houses and Landmarks,Route of Evacuation etc.

2.5 ROLE OF DISASTER MANAGEMENT AUTHORITIES, NGOS AND STAKEHOLDERS.

Plans for comprehensive Disaster Management are created at the federal, state, and local levels. The DM strategy will emphasise readiness, mitigation, and response at the national level. These plans contain evaluations of each party's capacity for reaction as well as a clear identification of their respective duties for each degree of catastrophe. (National Disaster Management Authority publication, 2009)

2.5.1 Guidelines—Preparation of Landslide Management Plans(National Disaster Management Authority publication, 2009)

- Preparation of state and district-level DM plans to manage**landslide** hazards.
- Revising town planning by-laws and adopting model land use by-laws in hilly areas. Wide dissemination of model land use practices in hilly areas.
- Training of trainers in professional and technical institutions.
- Training of professionals like engineers and geologists for landslide mapping, investigation techniques, analysis, and observational practices.
- Launching public awareness campaigns on landslide hazard and risk reduction, and sensitising all stakeholders on landslide hazard mitigation.
- Establishing appropriate mechanisms for compliance reviews of all land use bye-laws in hilly areas.
- Preparing an inventory of existing landslides, active or inactive, in India.
- Assessing the status of risk and vulnerability of the existing built Environment.
- Streamlining the mobilisation of communities, government agencies, the corporate sector, and other stakeholders.
- Creating DM plans at the Community and village levels, focusing on controlling landslides.
- Enforcing and monitoring the compliance of land use and town planning bye-laws and other safety regulations in landslide-prone hilly areas.

2.5.2 Role of Central Ministries and Departments

The central ministries and departments concerned will prepare their DM plans which will follow the National Guidelines on preparing state disaster management plans and shall cover all aspects of the disaster cycle for every disaster, including landslides. These plans will distinctly outline the steps that must be taken, the tasks that must be distributed among the various functionaries, the SOPs that must be adhered to, the methodology for completing the tasks that must be completed, and the deadlines for their completion.

2.5.3 Role of State Governments

In addition to creating its DM plans, state governments in landslide-prone regions will promote the creation of community preparedness plans to address local concerns, describe the connections between the different state support systems, and specify the purview of each department.

To promote the creation of the district, block, taluka/tehsil, and village DM plans, which would be improved, the GoI launched the GoI-UNDP Programme on Disaster Risk Management (DRM). The existing plans will be modified wherever required to streamline and optimise the response systems. These DM plans will be widely disseminated among stakeholders to create greater public awareness.

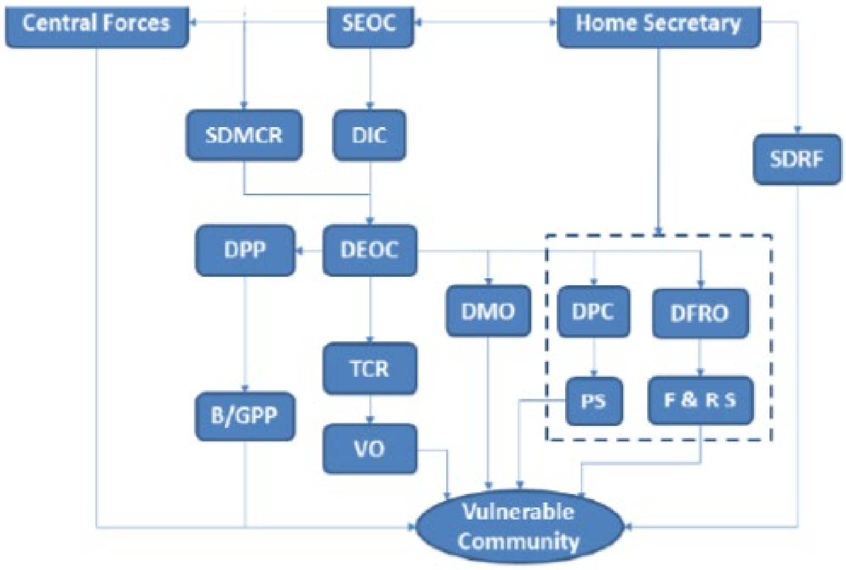
2.5.4 Role of Nodal Agencies

The responsibilities of the Geographical Survey Of India(GSI) as the nodal agency include coordinating all activities related to landslide hazard mitigation, monitoring the occurrence of landslides anywhere in India with the assistance of various departments of the central and state governments, coordinating and carrying out preliminary investigations of these incidences, reporting the same to multiple designated functionaries in the GoI and state governments, and carrying out Landslide Hazard Zonation (LHZ) mapping and other relevant studies. The GSI maintains a primary node of the Disaster Management Support (DMS) network that provides continuous connectivity with states vulnerable to natural disasters.

2.5.5 Role of District Authority

The 73rd and 74th constitutional amendments recognise Panchayati Raj institutions as **"institutions of self government".**

- The District Authority acts as the central district Planning authority, coordinating and implementing body for disaster management and take all measures for disaster management purposes in the district.
- Organise and coordinate specialised training programmes for different levels of officers &and employees, voluntary rescue workers &communities in the district.
- Facilitate community training and awareness programmes to prevent disaster or mitigation with the support of local authorities and governmental and non-governmental organisations.
- Provide advice, support, and coordination for the district-level departments of the government, statutory bodies, and other governmental and non-governmental organisations involved in disaster management.



SIC: State Incident Commander; DIC: District Incident Commander; SDMCR: State Disaster Management Control Room; DPP: District Panchayat President; TCR: Taluk Control Room; VO: Village Officer; B/GPP: Block/Gram Panchayat President; DPC: District Police Chief; DFRO: District Fire & Rescue Officer; PS: Police Station; F & RS: Fire & Rescue Station

Figure 2.16 Inter-communication Flow Chart between different stakeholders in case of Emergency.

Source: District police report,2016

Table 1 Roles of the Central Government Ministries and the Need for Inter-Ministerial Coordination in the Context of Landslide Management.

Ministry of Environment and Forests	Concerned with the protection of the lithosphere as a component of the Environment, and is responsible for putting policies, strategies, and action plans to protect mountainous landscapes and the associated Environment.
Ministry of Mines.	The GSI specifically addresses landslides.
Ministry of Home Affairs.	The nodal ministry is responsible for disaster management as a whole.
Ministry of Defence	The SASE and Defence Terrain Research Laboratory deal with snow avalanches and landslides.
Ministry of Power and Energy	Landslides are a problem for the Power Generated and the National Hydropower Corporation on several project locations.
Ministry of Urban Development and Poverty Alleviation	Responsible for projects connected with housing and human settlement. The CPWD and BMTPC deal with construction and hazard maps in landslide-prone areas.
Ministry of Water Resources	Responsible for the Development of Water Resources and especially those Related to Landslide Dam Problems.
Ministry of Railways	Landslides Affecting the Railway Network
Ministry of Science and Technologies	The DST promotes R&D on the diverse aspects of Technology landslides, climate change, etc. The Department ofEarth Sciences and laboratories of the CSIR is also engaged in studyingvarious aspects of landslide mitigation.
Ministry of Earth Sciences.	Newly constituted ministry responsible for earthquakes,
Ministry of Culture.	Responsible for protecting archaeological monuments and cultural and natural heritage threatened by landslides.
Ministry Of Tourism	Responsible for the development of tourism inecologically fragile areas.

2.6 IMPACTS OF 2018 LANDSLIDES IN IDUKKI

- According to the Government report, Idukki recorded 278 major landslides and 1800 mudslides which took 35 human lives along with the death of several animals and birds in the homestead.
- A total of 2667 houses were reported to be partially damaged and 755 houses wholly damaged.
- In some panchayats, sewerage, septic tanks and soak pits were disrupted or damaged by flood or landslides resulting in environmental pollution.

Impact on Flora and Fauna.

The landslides, debris flow and sedimentation were the main reasons for these losses. Further, many florae were also eliminated by the secondary fungal infections which developed subsequently. Many trees naturally established in the landslide area and planted mainly in the plantation and fruit sector have been uprooted. Root infections also brought down the health of trees.It is reported in the survey that the removal of surface soil through landslides had removed many innate beneficial microbial organisms.

Socio-Economic Impact in Idukki Region (Impacts on Community).

- The floods and landslide have damaged their houses and landed properties causing severe concern and agony. During adversity, most people had to stay back from routine activities to ensure protection for themselves and family members. This eventuality kept many from their regular jobs, forgoing their daily income.
- Many established plantations of coffee, tea, cocoa and banana were destroyed either wholly or partly beyond restoration.
- Breaches of roads on account of landslides snapped the transportation facilities, which indirectly affected the marketing and the freedom of people to move.
- The tribes of the Idukki district were also stressed during this period as they lost their cultivated land, dwellings, and in some cases, their domesticated animals. Further, due to adverse conditions, tribal people could not collect and market the minor forest produce like honey and lac from the forest, forcing them to run out of food for a few days.

- The loss of their study materials also hampered children's education. The psychological impact which every member of the house experienced was beyond description.

CHAPTER 3

STUDY AREA

This chapter discusses the Site selection methodology. The study area identified through site selection methodology is Rajakumary Grama Panchayath. The study area location, population, land use, transportation network etc. are studied. The results of the socio-economic survey conducted as a part of the primary study are also included in this chapter

3.1 SITE SELECTION METHODOLOGY

The site selection for the primary study was based on criteria starting from selecting the district upto the lowest level of Local Self Governments in the selected taluk. The three criteria for choosing the local body for primary study are socio-economic particulars, hazard vulnerabilities and ecologically sensitive areas of the region.

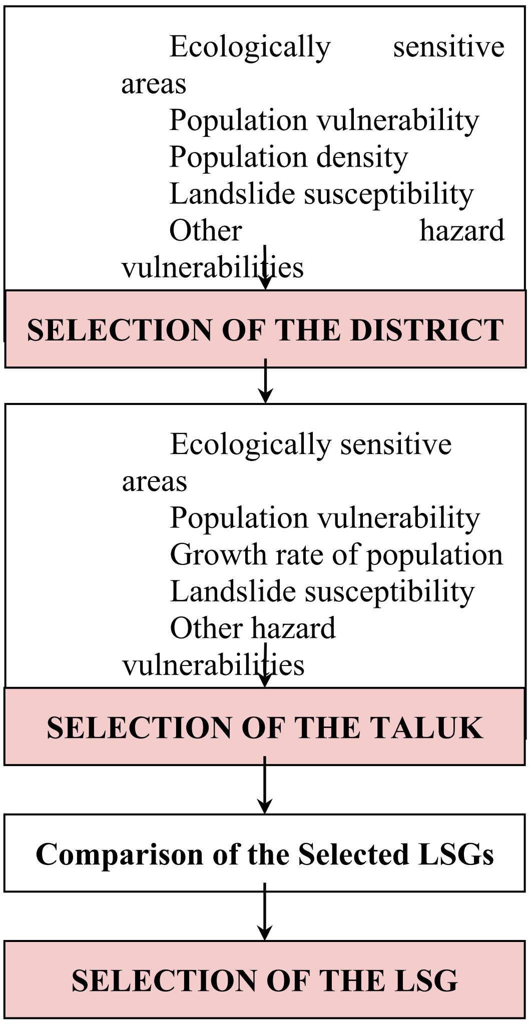


Fig 3.1 Site Selection Methodology

Source: Author Generated

3.1.1 Reasons Selection of the District

The state action plan for climate change 2016 has classified Idukki, Wayanad and Palakkad districts as the most vulnerable to disasters. According to the Kerala State Disaster Management Authority (KSDMA), 46.93% of landslides reported in Kerala during 2018 had occurred in the Idukki district.

Among the reported landslides, 4642 (98.18%) landslides occurred in the Western Ghats region. Also, 3903 (84.08%) fall within Western Ghats's Environmentally Sensitive Area (ESA). These landslides and floods resulted in the death of 483 persons and large-scale property loss. Around 5.4 million people were affected by this havoc, and more than 1.4 million people were displaced.

Table 3.1 Identification of the District

		Idukki district	Wayanad district	Palakkad district
1	Ecologically sensitive areas	4 taluks	3 taluks	2 taluks
2	Population vulnerability	Very high	High to moderate	High to moderate
3	Population Density	255	384	627
4	Landslide susceptibility	Very high	High to moderate	Moderate to low
5	Other major hazard vulnerabilities	High	High	Moderate
6	Topography	600- 2000m	600- 2000m	100-1000m
	TOTAL POINTS			

Source: 1) Western Ghats Ecology Panel, KSBB, 2011, 2) Census Hand Book, Idukki, 2011, 3) Kerala Disaster Management Plan, 2016, 4) District Urbanisation Report, Idukki, 2011

3.1.2 Identification of the vulnerable Taluk

Devikulam, Udumbanchola, and Peermedu taluks are most vulnerable to hazards and have more ESA land in the Idukki district.

Table 3.2 Selection of the Taluk

		Devikulam taluk	Udumbachola taluk	Peermade taluk
1	Ecologically sensitive areas			
2	Population vulnerability	Very high	High to moderate	Moderate to low
3	Growth rate of population	0-5	5-20	0-20
4	Landslide susceptibility	Very high	Moderate to low	Moderate to low
5	Other major hazard vulnerabilities	High to moderate	Very high	Moderate to low
6	Land use Pattern			
	TOTAL POINTS			

Source: 1) Western Ghats Ecology Panel, KSBB, 2011, 2) Census Hand Book, Idukki, 2011, 3) Kerala Disaster Management Plan, 2016, 4) District Urbanisation Report, Idukki, 2011

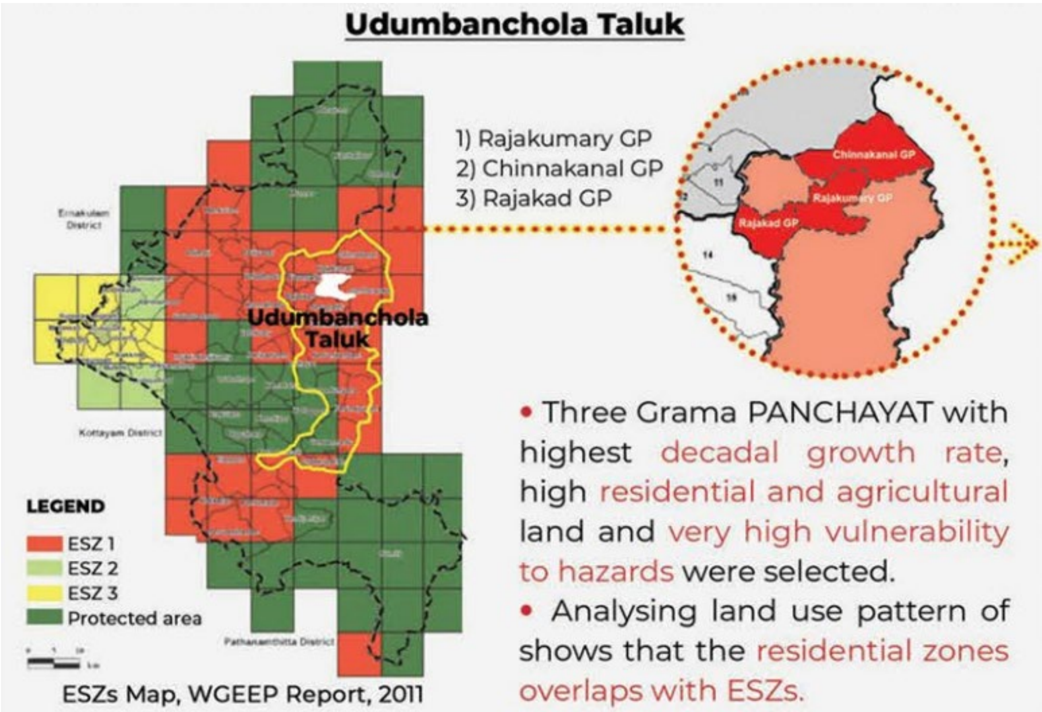


Fig 3.2 ESZs Map, Udumbanchola Taluk

Source:District Urbanisation Report, Idukki, 2011

3.1.3 Identification of LSG

Rajakumary Grama Panchayath is one of the panchayaths in the Idukki district with the highest growth rate, ESAs and risk vulnerabilities.

Table 3.3 Selection of the LSG

		Rajakumary GP	Chinnakanal GP	Rajakad GP
1	Area	38.15 sq.km	66.74 sq.km	31.03 sq.km
2	Population	16086	12949	14948
3	Density	421	194	481
4	Decadal Growth Rate	23.09	16.08	7.91
5	Concentration of Agricultural Labourers	1.6 - 2	1.1 – 1.5	1.1 – 1.5
6	Forest Land Use Concentration	< 0.5	0.5 - 1	< 0.5
8	Residential / mixed Land Use	> 2	0.5 - 1	> 2
9	No of BPL families	1369	1025	1844
10	Landslide Risk proximity	High	High	Low
	TOTAL POINTS			

Source: 1) Census HandBook, Idukki, 2011, 2) District Urbanisation Report, Idukki, 2011

3.2 STUDY AREA

3.2.1 Location and Context

Rajakumari village is in Udumbanchola taluka of Idukki district in Kerala, India. It is situated 32km away from sub-district headquarters Nedumkandam (tehsildar office) and 63km away from community headquarter Painavu. As per 2009 stats, Rajakumari village is also a gram panchayat with a total geographical area of38.15 sq.km. Rajakumari has a total population of 16,086 people. The literacy rate of Rajkumari village is 81.62%, of which 84.88% of males and 78.37% of females are literate. There are about 4,188 houses in rajakumari village

Table 3.4 Rajakumary Grama Panchayath details

1	**Block**	Nedumkandom
2	**Taluk**	Udumbanchola
3	**Area**	38.15 sq.km
4	**No. of wards**	13
5	**Rural**	
6	**No. of HH**	4188
7	**Population**	16086
8	**Population density**	421
9	**Villages**	1) Rajakumary 2) Poopara

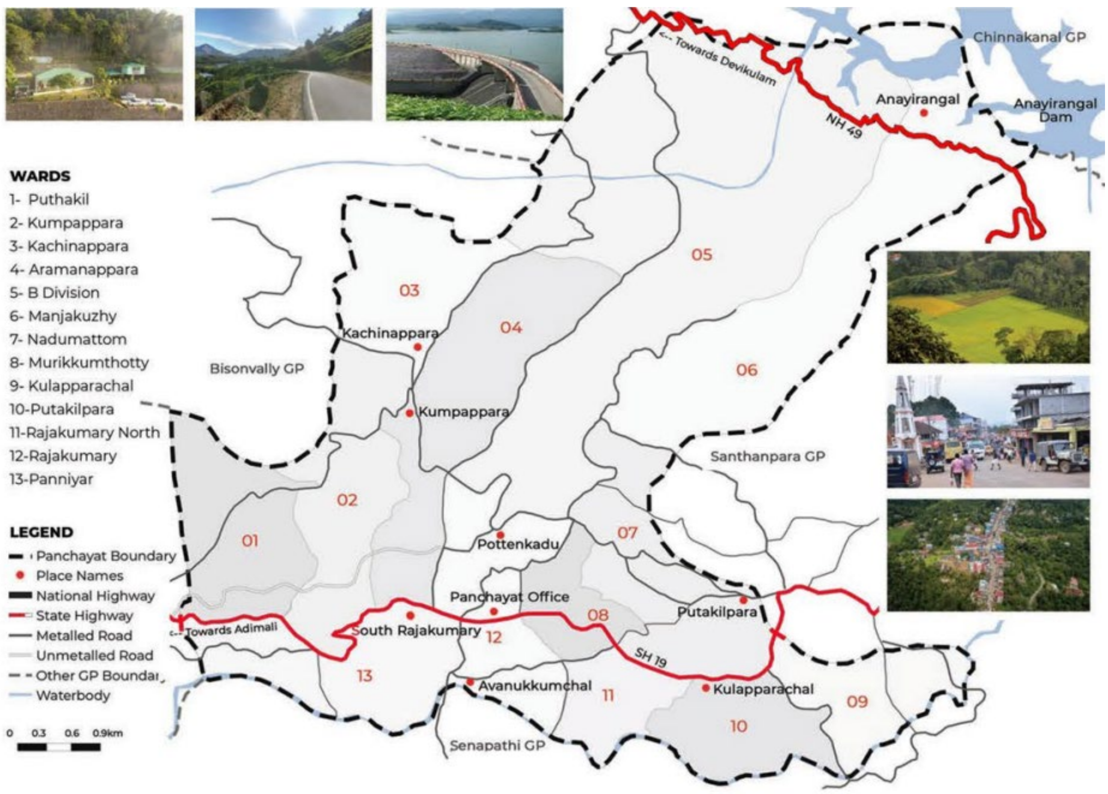
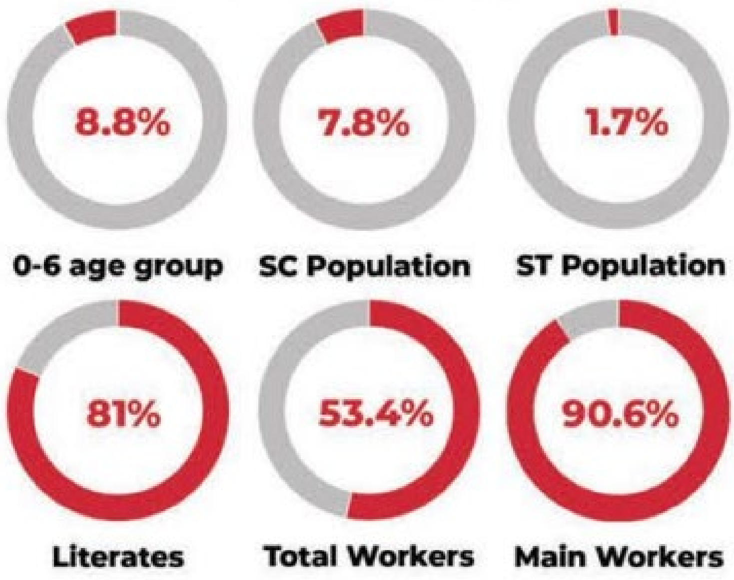


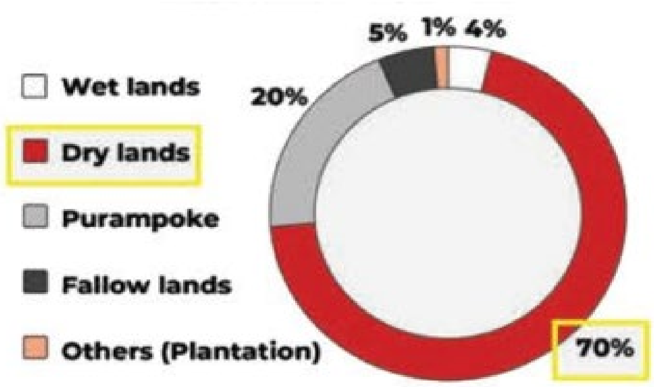
Fig 3.3 Base Map, Rajakumari Grama Panchayath

Source: Author Generated

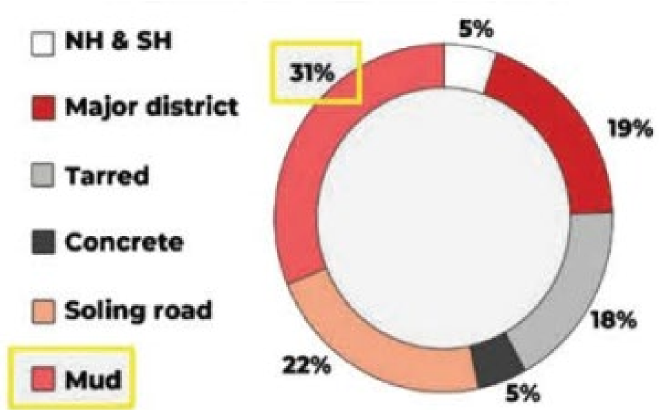
3.2.2 Demography



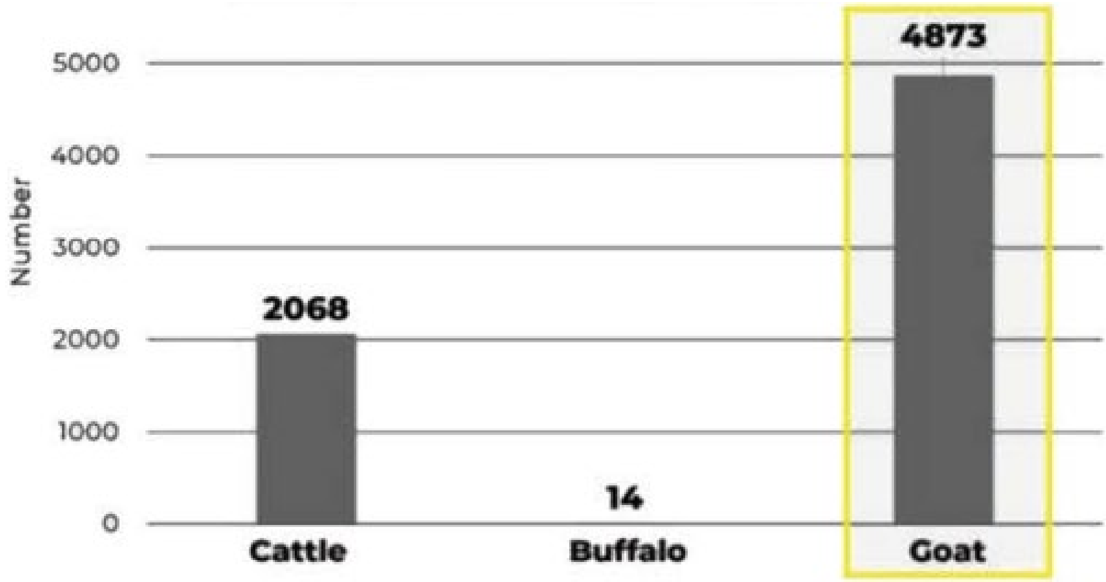
3.2.3 Type of Land



3.2.4 Road Classification

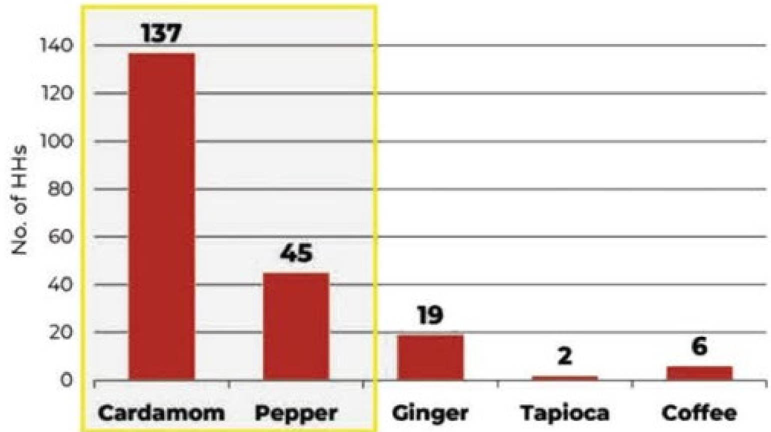


3.2.5 Livestock Population



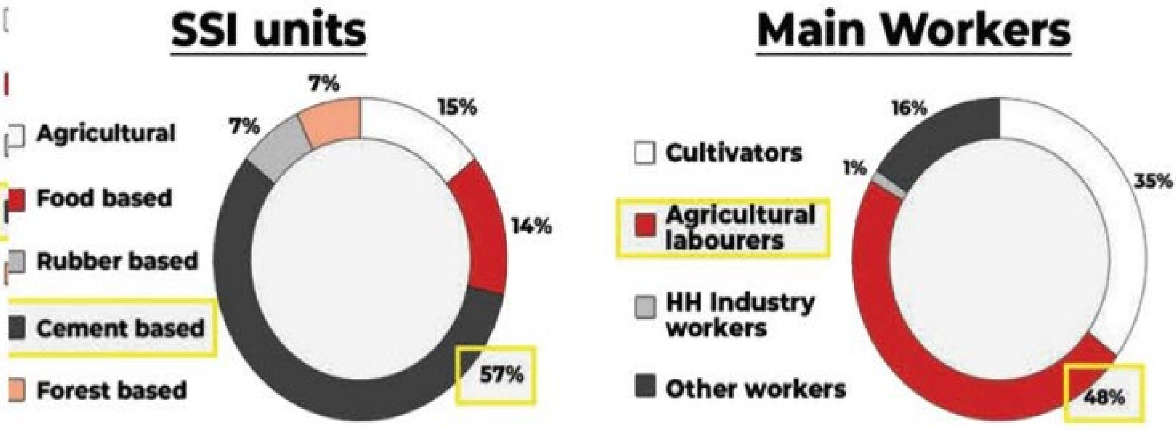
Studies have found that grazing contributes to biodiversity loss and adversely affects soil water retention capacity.

3.2.6 Illegal Possession of land under cultivation

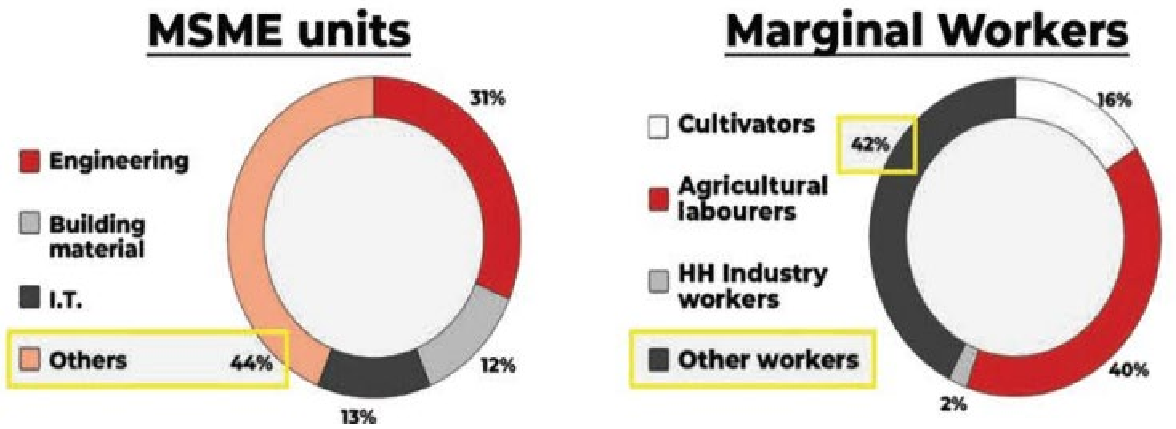


Illegal possession of land used for cultivation has increased rapidly, and the shift from mixed cropping to mono-culture has adverse effects on agriculture and biodiversity.

3.2.7 Workers



Anayirangal Dam is the major Ecologically sensitive Zone in the Panchayath.



3.2.8 Land Use

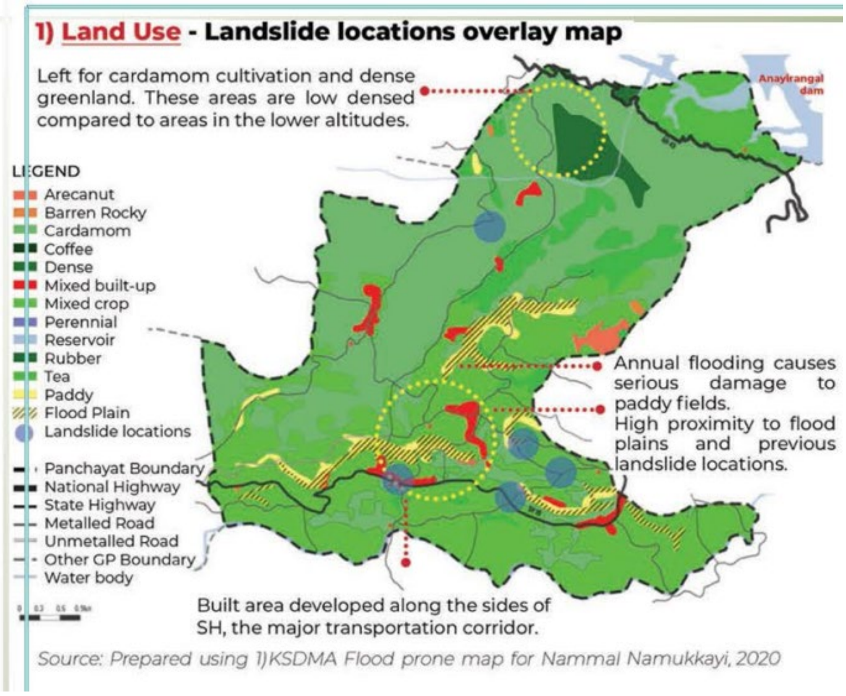


Fig :3.4 Land Use Map of Rajakumari Grama Panchayath

Source: Author Generated using 1) KSDMA Flood prone map for Nammal Namukkayi, 2020

3.2.8 Topography

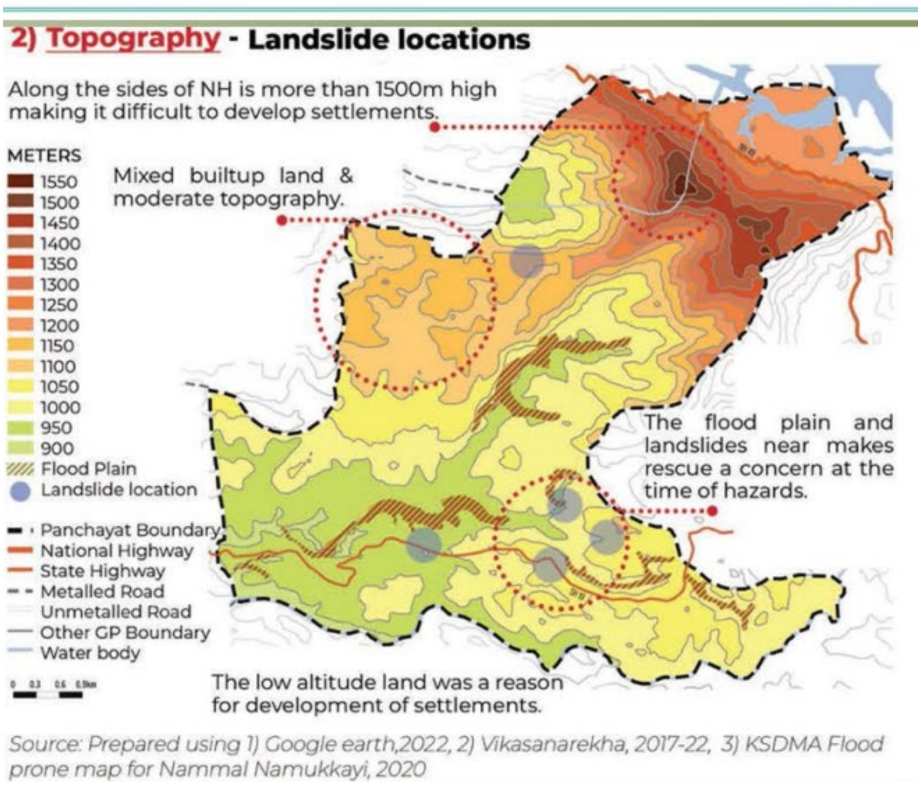


Fig :3.5 Topography Map of Rajakumari Grama Panchayath

Source: Author Generated using 1) KSDMA Flood prone map for Nammal Namukkayi, 2020

3.2.9 Flood Affected areas

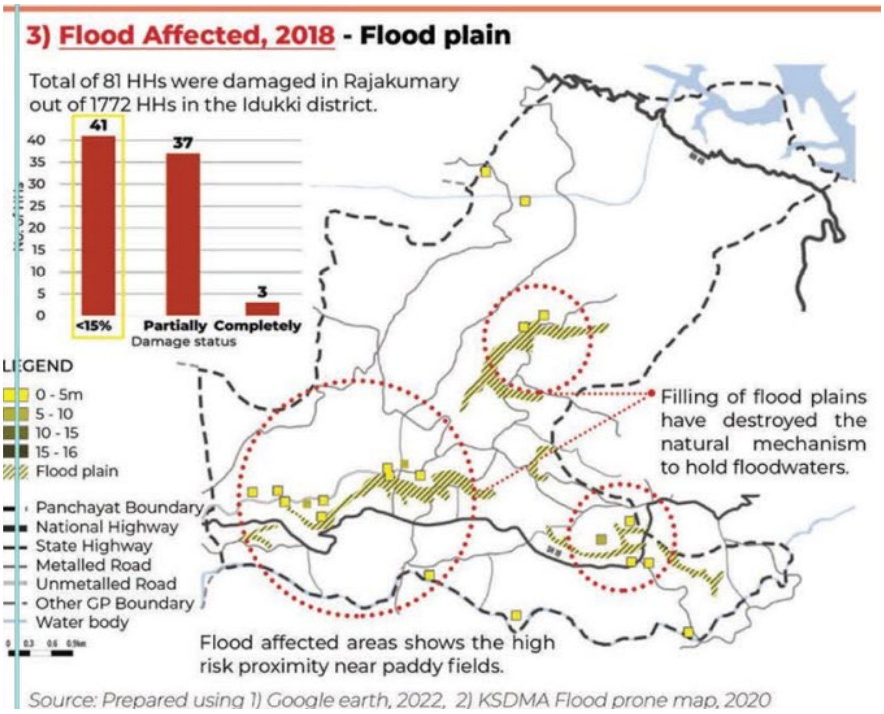


Fig :3.6 Flood affected Map of Rajakumari Grama Panchayath

Source: Author Generated using 1) KSDMA Flood prone map for Nammal Namukkayi, 2020

3.2.10 Infrastructure

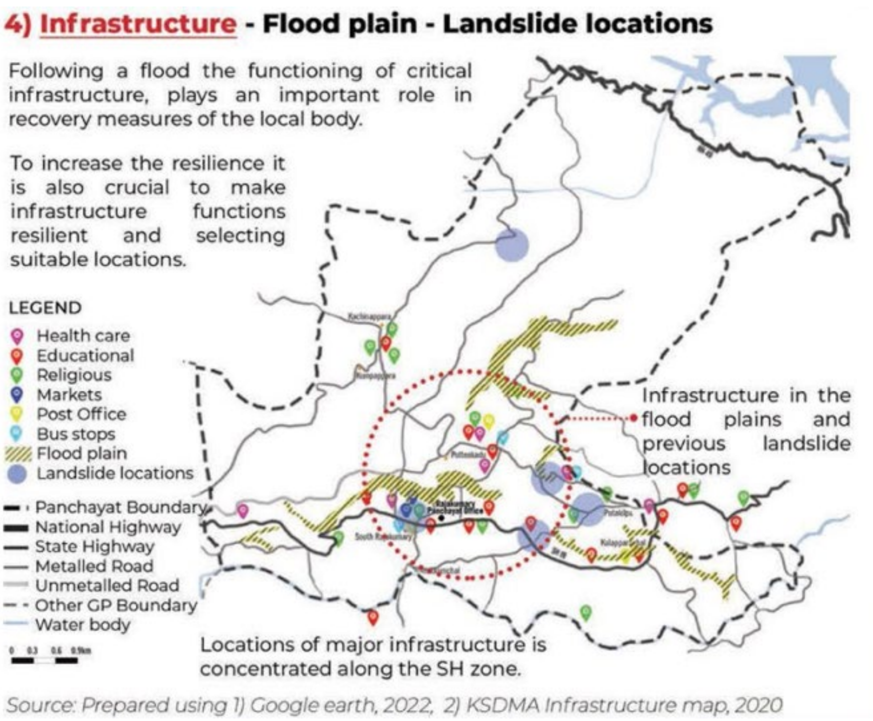


Fig :3.7 Infrastructure Map of Rajakumari Grama Panchayath

Source: Author Generated using 1) KSDMA Flood prone map for Nammal Namukkayi, 2020

3.2.11 Proximity to dams

Thirteen dams are located within 50 km of the panchayat and are thus vulnerable due to floods caused by dam failure. Experts suggest that uncontrolled mining, dam construction, deforestation, and poorly planned construction in sensitive areas have multiplied the risk of flooding and landslides.

3.2.12 Quarries

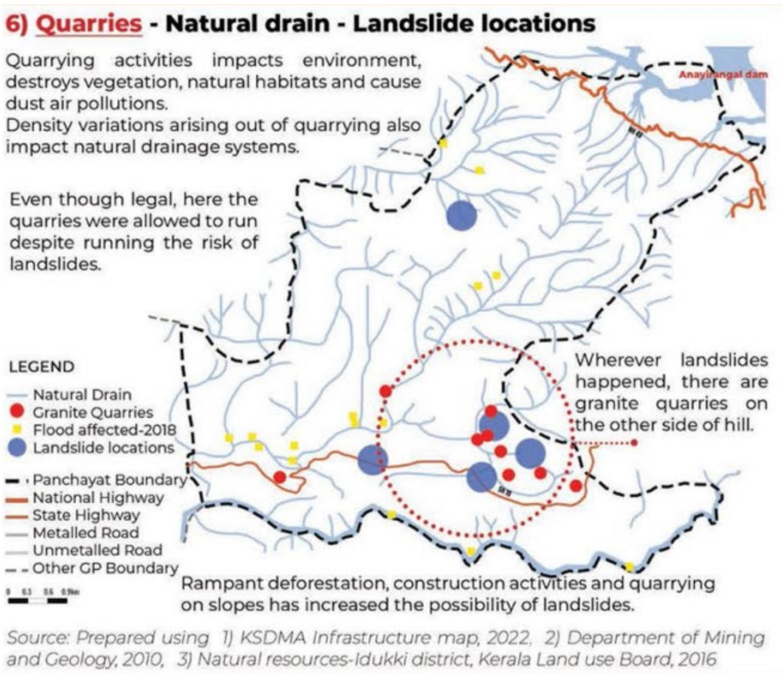


Fig :3.8 Quarries situated in Rajakumari Grama Panchayath

Source: Author Generated using 1) KSDMA Flood prone map for Nammal Namukkayi, 2020

3.3 INFERENCES

- The Gadgil report restricted shifting to Mono-culture crops, but it is the primary source of income here.
- The shift from forest uses to mono-culture cultivation can result in soil loosening in the future.
- Although a hilly region, high-risk areas in the panchayat are comparatively at the lower altitude areas comprised of mixed built-up density and paddy cultivation.
- High-altitude land is used more for agriculture due to the soil characteristics
- The development of the tourism sector adjacent to the reservoirs resulted in the rapid increase in heavy construction and development of resorts.
- Strict regulations for quarries are needed to reduce landslide occurrence.

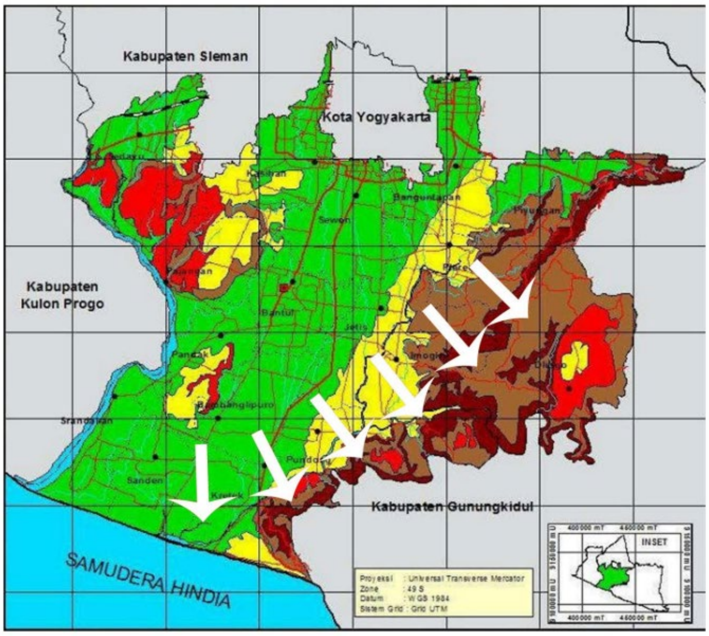
CHAPTER 4
CASE STUDIES

These case studies focus on the Community's engagement and many stakeholders who play a significant role in disaster management, both directly and indirectly. They relate to spatial planning in all stages of landslide disaster management. The Latin American study on Peru describes the participation and collaboration between a Team of scientists,experts and the local Community.The Indonesian research focuses on UNISDR elements as their significant way forward in Landslide Management.

4.1 MANGUNAN VILLAGE, BANTUL, INDONESIA

4.1.1 Location and Context

Out of the 75 villages in Bantul, there are 16 that are categorised as landslide-prone villages. One of them is Mangunan Village. This condition is caused by the geographical location of Bantul, in a contoured hilly(slope) area. The layer's depth is approximately 4000 m and almost entirely has a hill to the south. The vast majority of the Bantul District's regions on the west side are generally composed of rocks almost wholly formed by depositional processes.



The Map of Slopes of Bantul District
Source:S Aminatun et al 2021 IOP Conf. Ser.: Earth Environ.

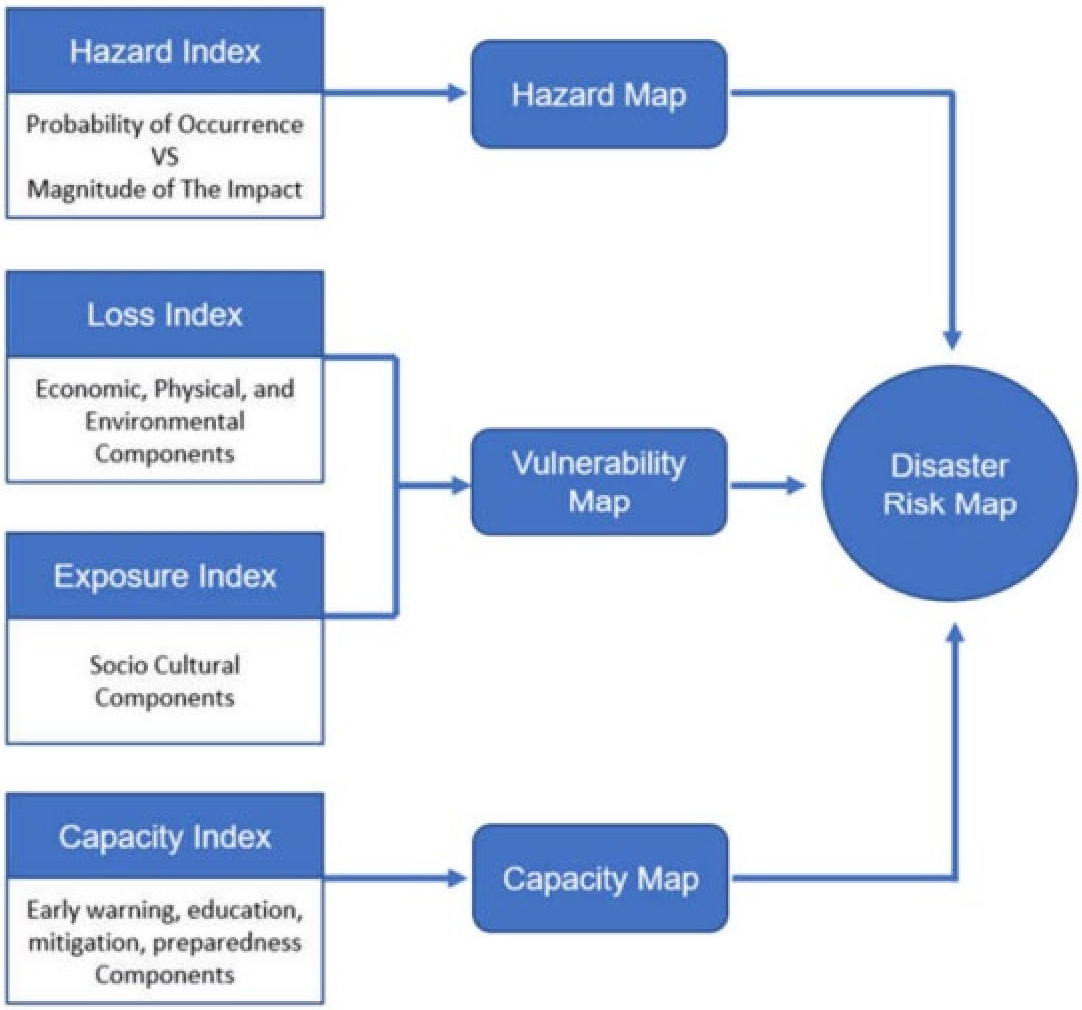
Fig : 4.1 Map Bantul District,Indonesia
Source: IOP Conference on Earth & Environment

4.1.2 Landslide risk assessment process

Aim: To analyse the risk of landslide in Mangunan Village

Steps taken

1) Detailing the disaster risk map, which constitutes a global risk map
2) Finding out the number of houses (households) in each disaster risk zone (red,yellow,green) and ;
3) Assess each risk parameter's values to determine the risk value of landslides. Ultimately, a disaster risk reduction program is developed to follow the risk analysis.

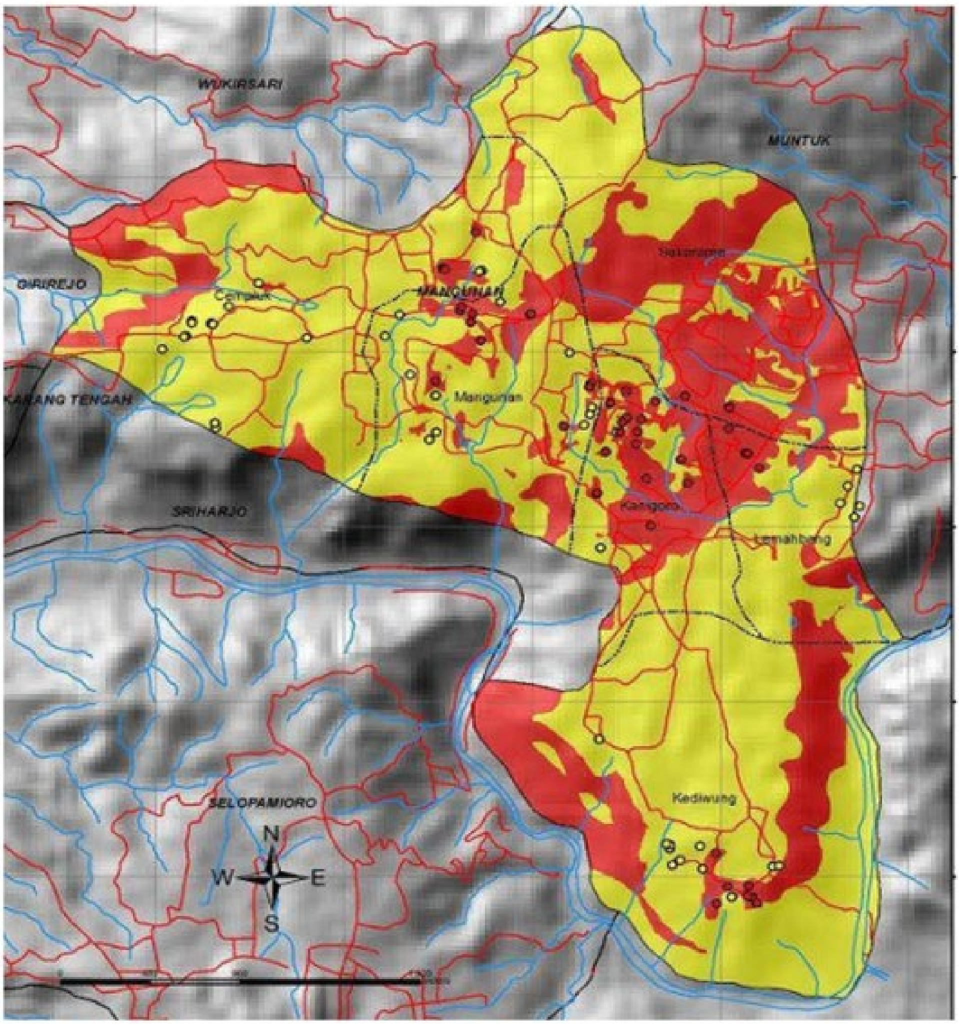


Flowchart of Risk Map Preparation
Source:S Aminatun et al 2021 IOP Conf. Ser.: Earth Environ.

Fig : 4.2 Flowchart of Risk Map preparation

Source: IOP Conference on Earth & Environment

$$Risk = Hazard\ x\ \frac{Vulnerability}{Capacity}$$



Risk Map of Mangunan Village,Bantul District,Indonesia

Fig : 4.3 Risk Map of Mangunan Village

Source: IOP Conference on Earth & Environment

Table 4.1 Weightage of Landslide Hazard Parameters

No	Parameters	Weight	Max. Score	Min. Score
1	Soil Texture Class	1	3	1
2	Soil Solum Thickness	1	3	1
3	Level of Rocks Weathering	1	3	1
4	Slope Inclination	5	15	5
5	Types of Morphology	3	9	3
6	History of landslides	1	3	1
7	Vegetation Density	1	3	1
8	Land use	1	3	1
9	Rainfall Data	1	3	1
	Total	15	45	15

Weighting of Landslide Hazard Parameters

Table 4.2 Weightage of Landslide Vulnerability Parameters

No	Assessed Elements	Weight	Score	Total
1.	Number of households in one house	1	2	2
2.	Number of family members in one house	1	3	3
3.	Home ownership Status	1	3	3
4.	Land ownership status	1	2	2
5.	Land Area	1	3	3
6.	Type of building	3	2	6
7.	Other land uses	1	3	3
	Total			**22**

Weighting of Vulnerability Parameters

Table 4.3 Weightage of Landslide Capacity Parameters

No	Assessed Elements	Weight	Max. Score	Min. Score
1.	Number of Hospitals, *Puskesmas*, *Polindes*	1	3	1
2.	Number of Schools	1	3	1
3.	Number of Medical Officers	1	3	1
4.	DRR Agency	1	3	1
5.	Evacuation Line markings	1	3	1
6.	Early Warning System	1	3	1
	Total	6	18	6

Weighting of Landslide Capacity Parameters

4.1.3 Development Programme Recommendations

1) High Risk

In high-risk areas, the disaster risk reduction option is relocation which means moving people from high-risk areas to safer places. The relocation areas should meet some requirements, such as

a) Houses should apply earthquake resistant concept,
b) Evacuation routes should have lanes so that four-wheeled vehicles can walk past each other,
c) Drainage systems work well, and worship places are available.

2) Moderate Risk

Some infrastructure needs to be constructed in these areas, such as retaining walls, drainage channels and evacuation routes.

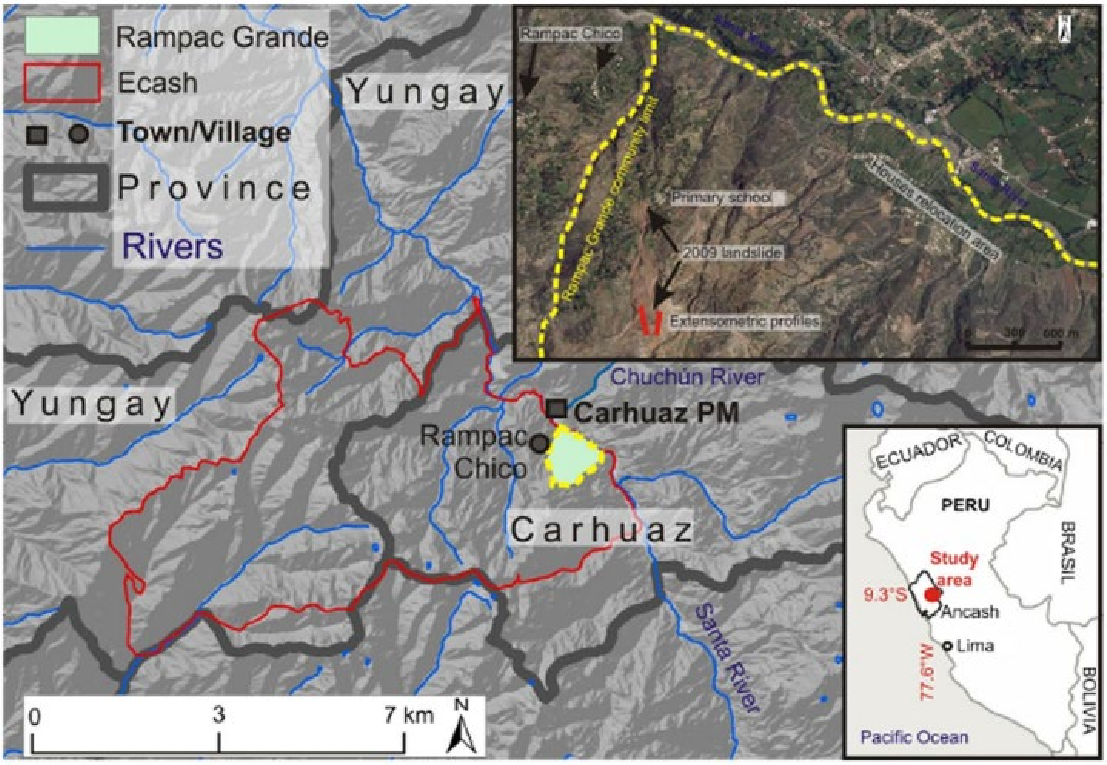
3) Low Risk

In these areas, existing conditions can be continued cautiously, and proper monitoring of Early Warning Devices should be done regularly.

4.2 RAMPAC GRANDE COMMUNITY, PERU, BRAZIL

4.2.1 Location and Context

Rampac Grande community is located on the NE slopes of the Santa River in Central Peru at the altitude of about 2900 masl. The valley is filled with Mesozoic and Tertiary sedimentary and volcanic rocks extensively covered by fluvial and glacial sediments. Precipitations and water saturation are also frequent landslide triggers in this area, apart from earthquakes. Rampac Grande community is a part of the Carhuaz District (population of about 15 thousand in 2017, roughly 33% of rural people; INEI 2018).



The Map showing study area location ,Rampac Grande community
Source:Community participation in landslide risk reduction: a case history from Central Andes, Peru

Fig : 4.4 Rampac grande community

Source: IOP Conference on Earth & Environment

The partnership between a group of scientists, including international and Peruvian professionals, and the local Community, which began following the 2009 landslide and concluded during the disaster risk reduction (DRR) initiative that ran from 2016 to 2017, is described in this paper. It demonstrates the transition from rejecting outside intervention to accepting the suggested measures and actively involving the Community in their implementation and upkeep. This was accomplished by reconsidering the function of local and scientific knowledge in the DRR process through improved communication and the appropriate application of participatory approaches.

To reduce hazards through the creation of hazard maps and the monitoring of landslide movement, community representatives must participate in the design of the DRR's intended outcomes.

In 2016, the INAIGEM research institute implemented a 2-year landslide DRR project(Fig. 2) to increase community resilience bypreparing a landslide hazard map, building a system ofwarning signs, and initiating landslide movement monitoring.The total cost of the DRR project was about 34,000 USD, from which about 9500 USD was spent on monitoring equipmentand related field installation works (placement of thewarning signs, extensometric profiles and information panelswith hazard maps).

Fig : 4.5 **Placement Of Warning Signs with Community Participation.**

Source: IOP Conference on Earth & Environment

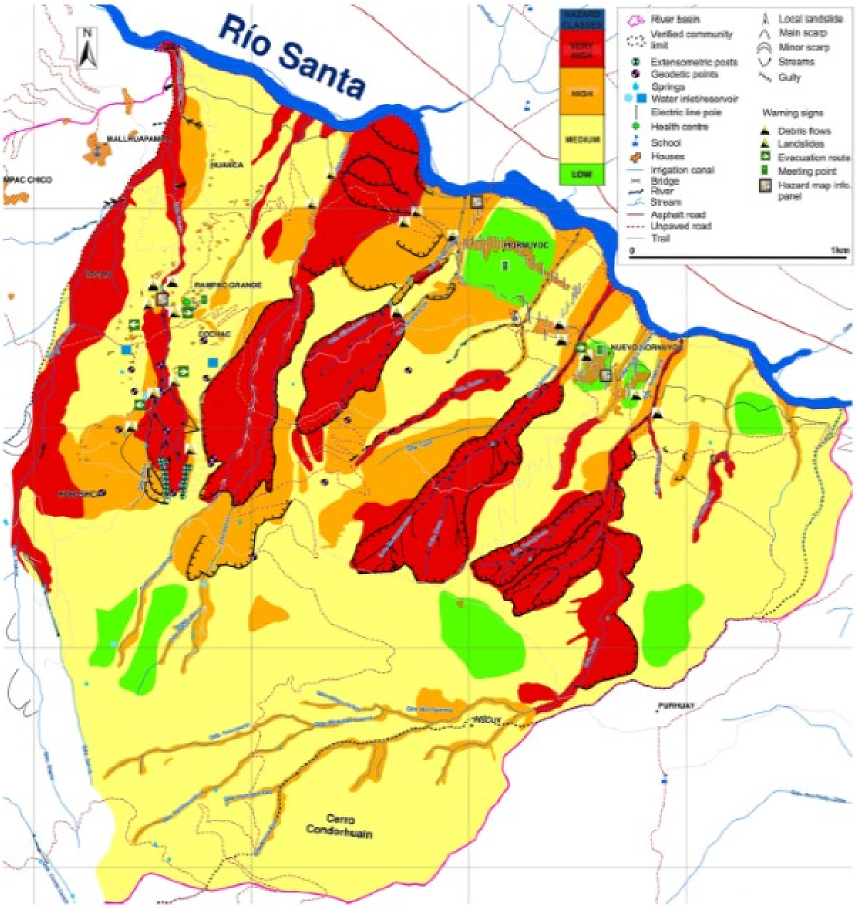


Fig : 4.6 **Evacuation Map of Rio Santa.**

Source: IOP Conference on Earth & Environment

4.2.3 Inference

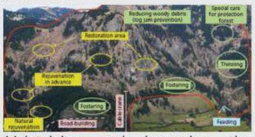
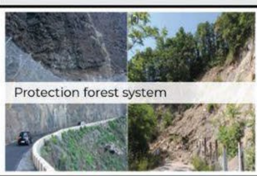
At the beginning of the DRR effort, the flawed assumptions about the community needs, inadequate communication between external experts and the Community, and limited resources mobilised for community involvement in the landslide DRR resulted in the un-aided self-help-based community action, relying solely on their local knowledge and adopting only minimal, provisional mitigation measures. It is shown how this approach changed during the 2016–2017 landslide DRR project when proper communication and sharing of scientific and local knowledge resulted in community acceptance and active participation in the DRR project and implementation of the mitigation measures.

The landslide DRR project illustrates how important it is to correctly describe stakeholders' roles and set an adequate risk communication strategy within the DRR, considering both the legal and informal authorities involved in the management process.

CHAPTER 5

BEST PRACTICES

The practises followed from three different countries are taken for study purposes ,the countries includes Brazil,Switzerland & states of Himachal & Arunachal pradesh.

	1) BRAZIL	2) SWITZERLAND	3) HIMACHAL PRADESH	4) ARUNACHAL PRADESH
Reason for Selection	Landslide hazard regulation and mitigation, creating resilience in the Serrana region of Rio de Janeiro State, Brazil 2011 • Similar Risk vulnerability • Eco DRR and CBDP methods a) Ecosystem- Tropical rainforests b) Hazards- Landslides, mudslides and flooding	Mountain ecosystems: Protection forests of Switzerland and other Alpine countries 2004 Measures and guidelines developed by governments to effectively manage Protection forests a) Ecosystem- Mountain b) Hazards- Mass movements, flooding	Climate Change Adaptation and HP Forests for Prosperity Project 2018 • Similar Risk vulnerability • Similar demographic character and livelihood a) Ecosystem– Himalayan glaciers b) Hazards- Avalanches, Landslides, Heavy rainfall, Drought	Biodiversity conservation through community-based natural resource management 2008 a) Ecosystem– Tropical forests b) Hazards- Landslides, Floods, Cloud bursts and Forest fires
Objectives	1) What is needed to improve land management at regional scale? 2)Which ecosystem-based measures are suitable for risk reduction in a mountain region of the tropics? 3)Develop and discuss ecosystem-based measures to reduce disaster risk based on the local knowledge?	1) How forests protect lives and assets in mountain areas? 2)Which elements influence the effectiveness of forests in mitigating natural hazards? 3)Political and economic measures being implemented by alpine countries to manage protection forests	1) Institutional Reform and Capacity Building for Integrated Watershed Management 2) Improved Forest Management 3) Improved Investments in Participatory and Sustainable Management 4) Bringing convergence of the development and environmental aspects in the state	1) Strengthen decentralized people's institutions to sustainably manage natural resources 2) Baseline mapping of natural resources and biodiversity surveys 3) Improved biodiversity through in-situ and ex-situ conservation measures
Risk Factors	Natural hazard factors • Torrential rainfall events • Steep topography • Narrow valleys • Soil type Environmental degradation • Deforestation • Agricultural land use intensification • Rectification of rivers Urbanisation and Infrastructure • Settlements on steep slopes • Road construction	Natural hazard factors • Increasing temperatures Urbanisation and Infrastructure • Shifting from predominantly agrarian to greater reliance on tourism • Infrastructure development	Natural hazard factors • Torrential rainfall events • Steep topography • Glaciers and snow changes Environmental degradation • Forest fragmentation • Rectification of rivers Urbanisation and Infrastructure • Large development projects • Locations of dams and abstractions	Natural hazard factors • Steep topography • Abrasion by the rivers • Deep valleys Environmental degradation • Shifting cultivation • Highly differentiated biodiversity Urbanisation and Infrastructure • Large hydropower projects • Focus on Industrial projects • Standardization of crops
Measures	Structural Measures • Hydraulic engineering structures • Canalization and bank stabilization • Slope stabilization • Terracing • Introduced agroforestry Non Structural Measures • Contingency Plans • Community based training on risk perception • Risk Mapping • Reforestation projects The damaged slopes are stabilized by creating sediment barriers made of Eucalyptus stakes and horizontal Bamboo sticks as well as using geotextile. Afterwards different leguminous species were planted to improve the soil conditions and quickly create dense vegetation cover.  Geotextiles for slope stabilisation	The protective benefits of a forest Forests used mainly to mitigate rock fall. Tree roots can prevent or reduce shallow landslides by mechanical reinforcement of the soil. The Swiss forest management system relies on private forest owners to promote the use of protection forests and follow forest management guidelines.  Maintaining and improving the functionality of protection forests using different nature based solutions  Protection forests in Switzerland	Structural Measures • Slope stabilisation • NBS in communities • Climate smart agriculture Non Structural Measures • Participatory forest management • Water institutions • Preparation of contingency plans • Capacity Building • Citizen Engagement Framework • Gender Strategy • Tribal Development Framework • Monitoring Strategy • Capacity Building Strategy Provide separate trainings to women for upgrading their skill and putting them to use.  Climate smart agriculture nursery	Structural Measures • Forest landscape Restoration • Agroforestry • Bamboo plantations • Slope stabilization Non Structural Measures • Encouraging traditional knowledge and decentralizing management • Biodiversity conservation as a means • of mitigating risks to Livelihoods • Community Conserved Area Encourage the multi-stakeholder approach to achieve convergence among different departments and Agencies. Develop incentives for promotion of biodiversity. Mitigate their impacts on biodiversity and develop a community strategy to address the mitigation measures.  Terracing and agroforestry
Finance	Payment for Ecosystem Services (PES) is a tool for paying land owners, such as farmers, for protecting critical ecosystems which provide valuable goods and services.	The Government of Switzerland has spent 120-150 million Swiss francs per year over the past decade. 67% of protection forests in are privately owned . 33% public	Promoted a participatory and sustainable management through financing the planning and investments in selected catchments. A combination of public investments, and partnerships with other public agencies.	United Nations Development Programme (UNDP)
Lessons Learned	• Establishment of riverine vegetation under the national forest code and partnerships among stakeholders. • Processes of environmental education, reinforcement of laws and recovery of forest covers as part of the long-term planning process.	• The development of high-quality guidelines and trainings for foresters to ensure proper implementation of recommended measures. • Natural capital and landscape enhancement	• Engaging the local community members helped generating better outcomes. • Private barren lands developed as plantation. • Communities had significant role in detecting, informing and extinguishing the forest fires.	• Biologically diverse tropical forest and built capacities of local communities to conserve and manage eco tourism. • Crafted village level institutions for the Protection of biodiversity on the basis of information gathered.
	 The restoration project implemented	 Protection forest system	 Student Community groups	 Community mapping and discussions
INFERENCE	Natural hazard factors • Climate change impacts • Due to human activities on environment and biodiversity Urbanisation and Infrastructure • Heavy projects in sensitive areas • Constructions disturbing the natural waterline	Structural Measures • Nature based solutions or ecosystem based approaches have also contributed income Non Structural Measures • Well-managed ecosystems, act as natural infrastructure, reducing physical exposure and increasing socio-economic resilience	• Encourage new types of financial incentives for investments in sustainable management • Unlock new investments and Work with the private sector	• Provide cost-effective natural buffers against natural events and the impacts of climate change • Healthy and diverse ecosystems are more resilient to extreme weather events • Human conflicts in decisions can cause devastation to communities

CHAPTER 6
ANALYSIS & INFERENCES

6.1 MAPPING

The intensity of hazards is expressed as different spatial maps using information from historical events to define the probability of occurrence as High,Medium & Low.The parameters considered for the preparation of both the hazard & Impact Mapping are,

- Slope/Elevation
- Soil Morphology
- Landuse
- Rainfall
- Quarry Density
- Historic Landslides
- Distance to drainage
- Road Density

Table 6.1 **Weightage of Hazard Parameters & their probability of occurrence**

Conditioning Parameters	Insite conditions	% of occurrence
• Slope/Elevation	More than 30 degree	44.03%
• Soil Morphology	Migmatite & peninsular rocks	64.5 %
• Landuse	Plantation	27.8%
• Rainfall	875-905mm	49.2%
• Quarry Density	0-.00025	52.25%
• Historic Landslides	More than five landslides	70%

● Distance to drainage	0-75m	46.02%
● Road Density	.06-1.5	39.5%

Table 5.1

Source: Author generated from WGEEP report

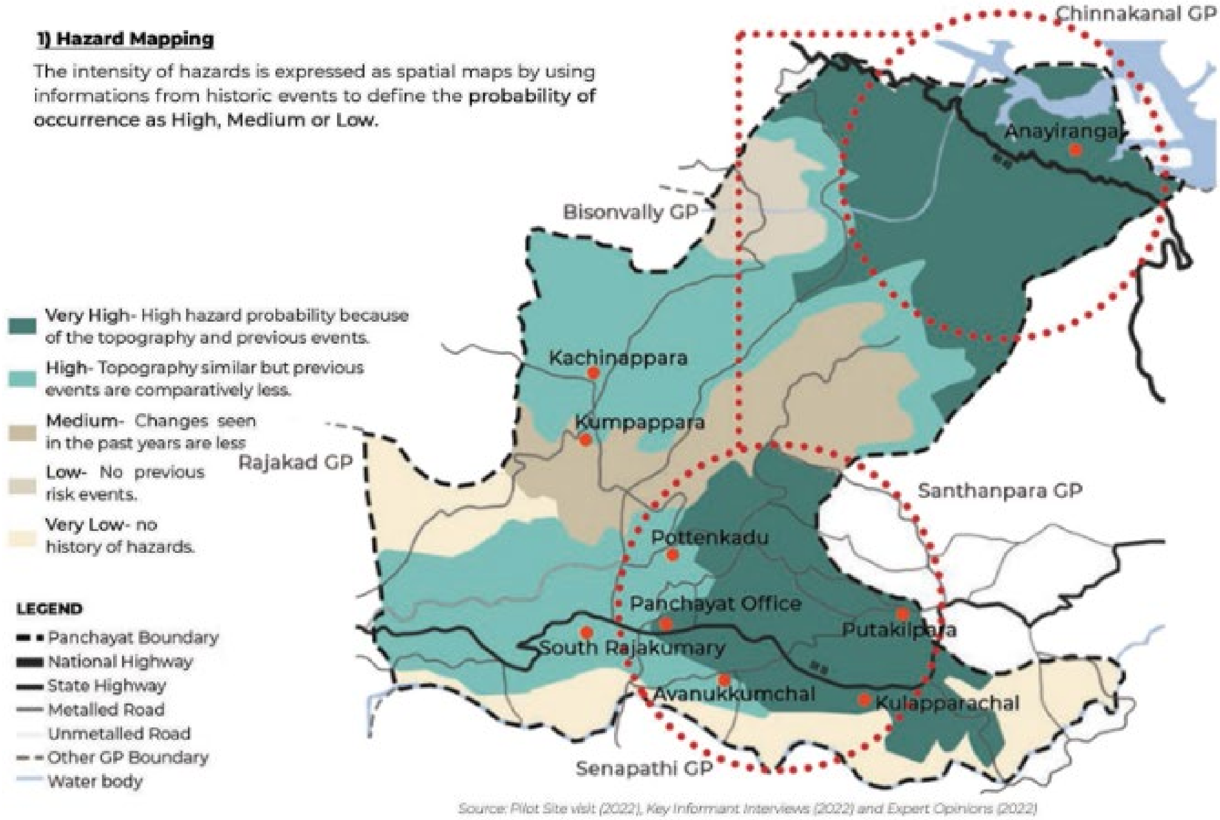


Figure 6.1 Landslide Hazard Zonation Map of Rajakumary Gramapanchayath

Source: Author generated using pilot site visit & WGEEP parameters

6.2 INFERENCE

The above-discussed hazard parameters can be identified as having localised towards High hazard probability areas. The areas to the North & South of Rajakumary Gramapanchayath are identified with very high hazard probability because of the topography and previous events.Also, areas of very low hazard probability are specified in the panchayat's central regions, where the topography and built-up lands are familiar. These areas must be protected from future Landslide Hazards, and proper Disaster Management efforts must be taken to minimise the hazard Impacts.

CHAPTER 7
PROPOSALS

7.1 Evacution Mapping

The hazard prone areas that are identified from the Hazard mapping are used for the identification and creation of a landslide evacuation map for Rajakumary Gramapanchayath. The Evacuation Map provides a list of helpful institutions and evacuation routes in a disaster.Roads to be followed to reach safe areas easily are identified and marked, and the different healthcare and educational institutions are labelled along the tracks. Other warning signals are placed at regular intervals along the evacuation routes and the location of sensors are also placed and marked in an evacuation map.

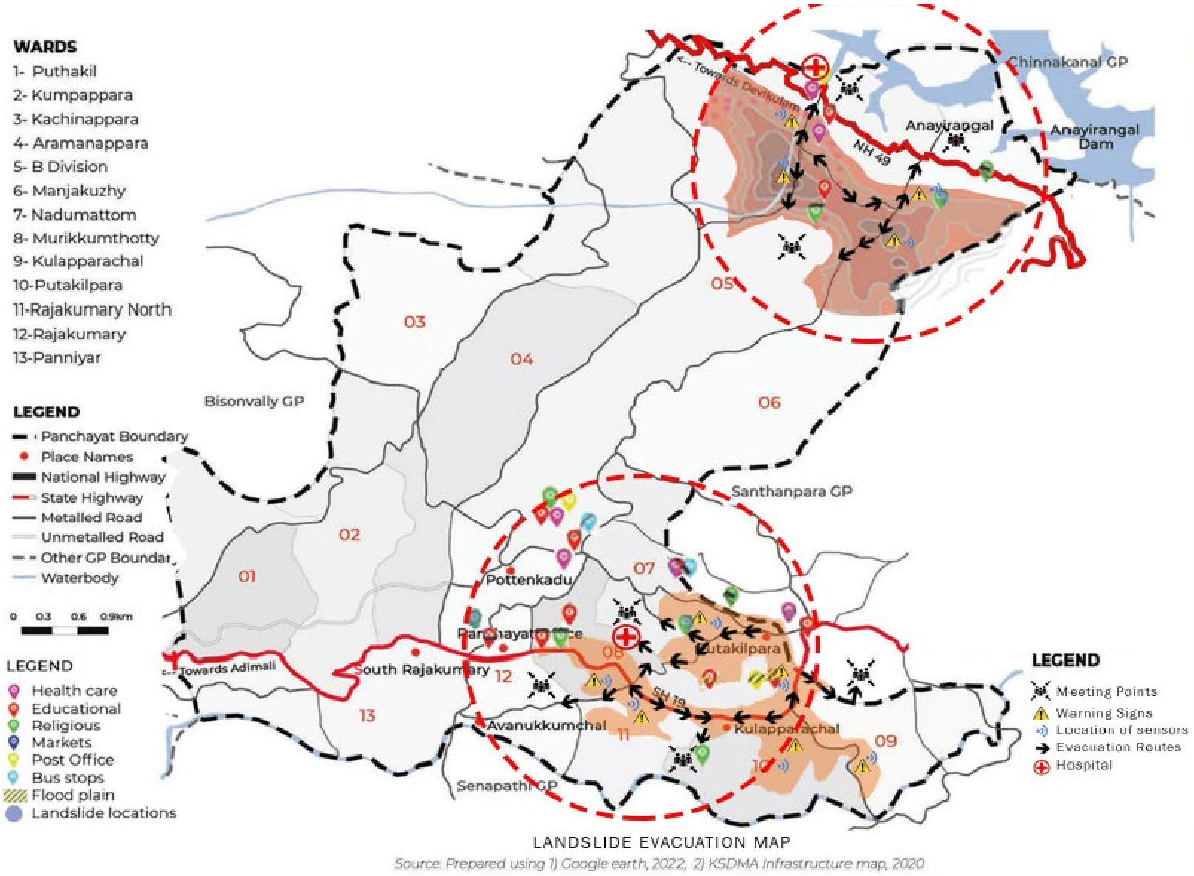


Figure 7.1 Landslide Evacuation Map of Rajakumary Gramapanchayath

Source: Author generated

7.1 Landslide Mitigation Measures

Landslide disaster mitigation measures includes several environment protection ways that can be implemented with the help of community participation .Local inhabitants support and participation is a must for the effective success of these mitigation process .Several measures like agroforestry , monoculture, crop diversification etc are soil quality enhancing and protecting measures that increases the porous pressure of soil,which thereby increses the water holding capacity . Other mitigation measures includes Geo-textiles, outreach events(events for experiencing the ecosystem) and introduction of data hubs that displays sesonal calender, resource and hazards data in local languages at selected nodes.Special regulations must be implemented to regulate Quarrying and proper community monitoring should be done to ensure the same.

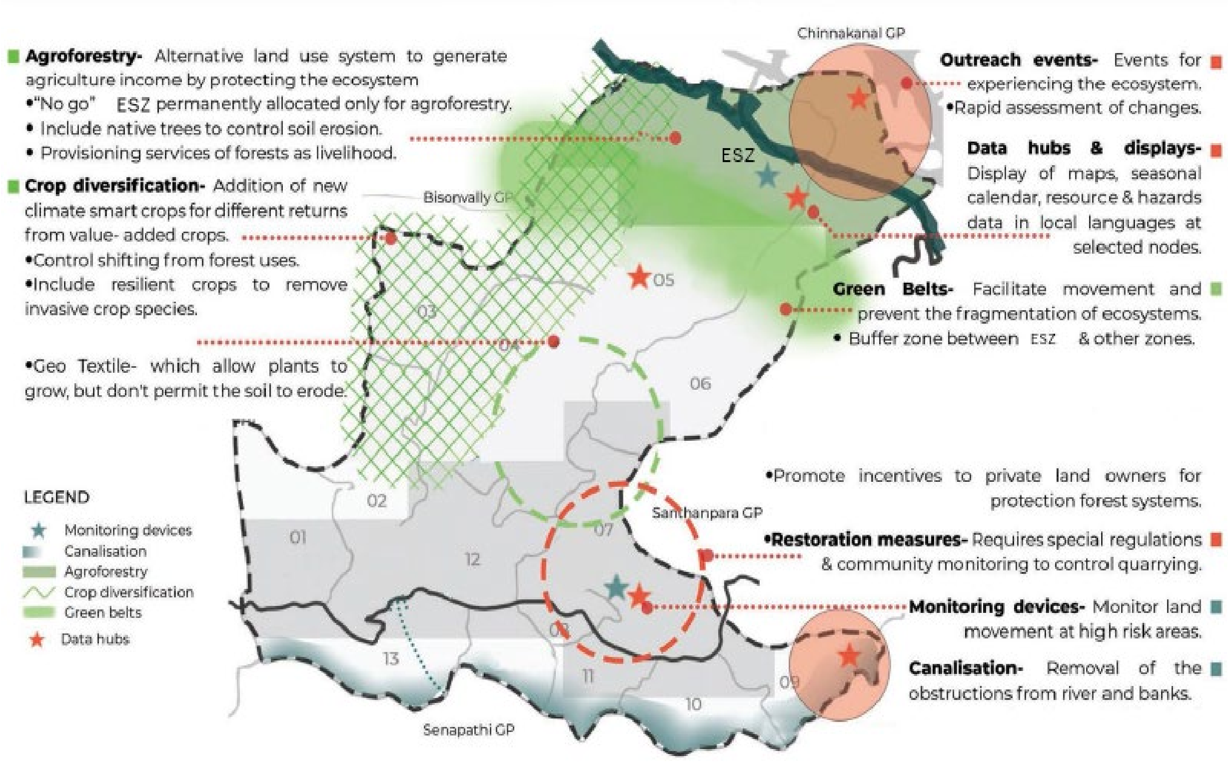


Figure 7.2 Recommendations for Disaster Mitigation measures -Rajakumary Gramapanchayath

Source: Author generated

CHAPTER 8
CONCLUSION

Kedarnath tragedy in the last decade. The landslides in August 2018 in Kerala were one of the most devastating events after 2013. Idukki district was the worst affected by floods and landslides. Apart from the natural causes over which humans have no control, lack of scientific interventions for sustainable developmental activities and lack of Spatial Planning in case of Disaster Management, including Community Participation, is observed as the primary reason behind such landslide disasters causing loss of life and property in Idukki District. Through carefully Spatial Planning in the case of Risk Assessment and Mapping involving the Participation of Local Communities, we can minimise the impacts and aftereffects of these Landslides to a great extent.

8.1 RECOMMENDATIONS

- The culture of awareness generation and preparedness must be disseminated; so that all people in the society can become alert and aware in case of an emergency or before the disaster strikes to take preventive measures.
- In Kerala, a paradigm shift from post-disaster response to pre-disaster prevention should be focused on preparedness and mitigation strategy. There is an immediate need to make local people aware of landslides to reduce losses.
- The current engineering practice relies on fragmentary approaches involving quick-fix treatments of landslides, which end up in their recurrence, year after year, at the exact locations. The permanent solutions to our major landslide problems may appear at face value to be capital intensive and even unaffordable. Still, in the proper analysis, the benefits of permanently fixing landslides will far outweigh.
- Appropriate agencies, institutions and teams should be identified, shortlisted and mandated to implement the management strategies for all the known problematic landslides in the country.

- Knowledge may be accessed in communities by teaching the weak about necessary mitigation strategies and tackling floods from an inclusive perspective.

- Mitigation of landslide sites will be done based on Detailed Project Reports (DPRs) submitted by the concerned States / UTs as per the NDMA and components of UNISDR for the participation of the Community in landslide risk mitigation.

- the Group of Experts will scrutinise DPRs based on Cost-Benefit Analysis.

- Monitoring, inspections & audit of mitigation work by Expert Group and focusing on ensuring that a Participatory approach is being carried out.

CHAPTER 9

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