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Wayanad's Landslide Crisis: A Multi-Dimensional Review of Geohazards, Socio-Cultural Disruptions, and Sustainable

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Report on

Wayanad's Landslide Crisis: A Multi-Dimensional Review of Geohazards, Socio-Cultural Disruptions, and Sustainable Solutions

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CHAPTER I

INTRODUCTION

1.Introduction

Landslides represent one of the most catastrophic and devastating natural disasters in the world, particularly in regions with complex geomorphology and high rainfall, often resulting in significant loss of life, damage to property, and disruption of ecological balance. Earth materials are displaced through various processes, including rock falls, surface sliding, flowing, and avalanches. These movements often manifest as earthflows, mudflows, debris flows, and creep. Broadly, landslides are triggered by two primary factors: natural causes and human interventions. The frequency of landslides in hilly regions is exacerbated by human activities, such as urban expansion and the construction of engineering structures like roads along slopes (Gupta M et al., 2009; Kyriou A and Nikolakopoulos K, 2018; Mani S &Saranaathan SE, 2017) Natural triggers are influenced by a complex interplay of factors, including rainfall, lithology, geological structure, geomorphology, drainage patterns, slope gradients, vegetation, soil cover, land use, and the hydrological regime (Reis S, 2008). Wayanad, a district located in the northeastern part of Kerala, India, has emerged as a hotspot for such geohazards, particularly during the monsoon season. This region, characterized by its rugged terrain as part of the Western Ghats—a UNESCO World Heritage site—has witnessed an alarming increase in the frequency and intensity of landslides over the past decade (Kumar & Shetty, 2021). These landslides not only cause significant loss of life and property but also lead to long-term environmental degradation and socio-economic disruptions.

The vulnerability of Wayanad to landslides is largely attributed to its unique geographical features and climatic conditions. The region's steep slopes, coupled with high-intensity rainfall, contribute to the destabilization of soil and rock formations, triggering landslides (Kuriakose, Sankar, & Muraleedharan, 2009). However, the increasing anthropogenic pressures, such as deforestation, unplanned construction, and agricultural expansion, have exacerbated these natural vulnerabilities, turning Wayanad into a landslide-prone zone (Bhattacharya et al., 2019). The landslide events in recent years have highlighted the urgent need for a comprehensive understanding of the underlying causes and the implementation of effective mitigation strategies.

The 2019 landslides, which claimed over 60 lives and displaced thousands, served as a wake-up call for policymakers, scientists, and local communities (Sreekumar, 2020). This report seeks to analyze the Wayanad landslide events, focusing on the interplay between natural and anthropogenic factors that contribute to such disasters. Furthermore, it will explore the impact of these landslides on the local population, economy, and environment, and review current mitigation efforts. The report will also provide recommendations for future disaster risk reduction strategies,

emphasizing the need for a balanced approach that integrates environmental conservation with sustainable development.

Wayanad, a hilly district in the Western Ghats mountain range, is vulnerable to landslides during the monsoon season. The total population of Wayanad district 846,637 (Annual Vital Statistics Report, 2018) and density 397/km^2 (823 sq mi). A significant landslide occurred in the early hours of Tuesday, 30 July 2024, followed by multiple additional incidents throughout the day, including in the afternoon. The landslide started at Mundakkai, followed by three subsequent landslides that occurred within three hours. The areas that have been most hit include Chooralmala, Attamala, and Mundakkai. The disaster resulted in the collapse of the main bridge linking the affected area to the nearest town, Chooralmala, significantly impeding rescue operations. Moreover, the India Meteorological Department's (IMD) forecast extremely heavy rainfall throughout the day in the area.

The Wayanad region in Kerala, India, has experienced significant landslides, particularly during the monsoon seasons of 2018 and 2019, leading to considerable loss of life and damage to property (Abraham et al., 2020). To address this, research has been conducted to develop a Landslide Early Warning System (LEWS) by establishing rainfall thresholds that could trigger landslides, using both Bayesian and Frequentist statistical approaches (Abraham et al., 2020). Additionally, landslide susceptibility zonation (LSZ) maps have been created using remote sensing and GIS, considering topographical and climatic factors, to aid in disaster management (Arumugam et al., 2023). Further detailed surveys in the Vythiri taluk of Wayanad have been carried out to develop a landslide susceptibility map using the frequency ratio (FR) model, which considers a variety of factors influencing landslides (Vinayan et al., 2022).

Interestingly, while the studies in Wayanad focus on rainfall as a major triggering factor for landslides, they also incorporate a range of other factors such as topography, land use, and vegetation (Arumugam et al., 2023; Vinayan et al., 2022). The methodologies employed in these studies vary, from statistical analysis to remote sensing and GIS-based approaches, indicating a multi-faceted effort to understand and mitigate landslide risks in the region.

2.Overview of the Wayanad District

Wayanad District, often referred to as "The Green Paradise," is situated in the Malabar region of Kerala, spanning an area of 2,132 km² between the coordinates E.Long 75° 47' 23" to 76° 26' 40" and N.Lat 11° 30' 08" to 11° 58' 40". This border district, established on November 1, 1980, by merging the northern and southern regions of Kozhikode and Kannur districts, adjoins the Mysore plateau to the northeast and is contiguous with the Nilgiris of Tamil Nadu.

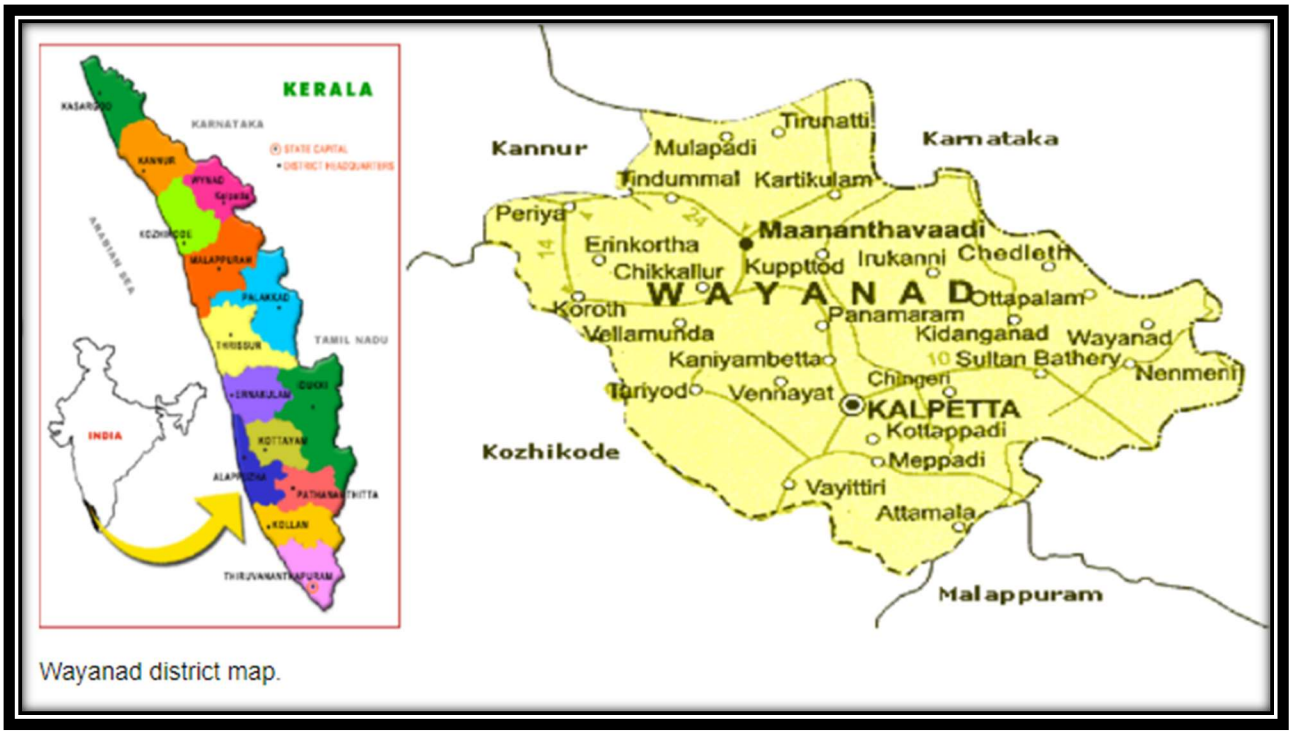


Fig 1: Location map of the Wayanad District

Wayanad is a picturesque district in the northeastern part of Kerala, India. Known for its lush greenery, mist-covered mountains, and rich cultural heritage, Wayanad is a popular destination for nature lovers and adventure enthusiasts. Situated on the southern tip of the Deccan Plateau, Wayanad is bordered by the Western Ghats, which gives it a unique topography. The district is bordered by the districts of Kozhikode and Malappuram within Kerala, as well as the neighboring states of Karnataka and Tamil Nadu, making it strategically important. The district's geographical location places it in a high-altitude region, with elevations ranging from 700 to 2,100 meters above sea level. This positioning within the Western Ghats contributes to its lush landscapes, diverse flora and fauna, and its susceptibility to various natural processes. Wayanad covers an area of approximately 2,132 square kilometers. The total population of Wayanad district around 846,637 (Department of Economics and Statistics, Government of Kerala.,2020). and density 397/km^2 (823 sq mi). Wayanad district in Kerala, India, is administratively divided into three taluks: Vythiri, Mananthavady, and Sulthan Bathery. These taluks encompass a total of 49 villages and are further organized into 49 panchayats, which serve as local governing bodies. This structure is tailored to manage the district's predominantly rural population and the region's diverse natural and cultural resources, ensuring efficient governance across its scenic landscape. According to the 2011 Census, Wayanad had a population of 817,420, comprising 401,684 males and 415,736 females. The district recorded an average literacy rate of 89.03% in 2011. Additionally, the sex ratio stood at 1,035 females per 1,000 males, an improvement from the 2001 census figure of 995. The district is predominantly rural, with a significant tribal population, contributing to its cultural diversity. The district enjoys a pleasant climate year-round, with heavy monsoon rains from June to

September. The average temperature ranges between 20°C to 30°C. Wayanad's economy is primarily agrarian, with a strong focus on cash crops such as coffee, tea, pepper, cardamom, and spices. The district is also known for its paddy fields, especially in the lower altitude regions. Wayanad is a major tourist destination in Kerala, attracting visitors with its natural beauty, wildlife sanctuaries, waterfalls, and historical sites. Popular tourist spots include the Wayanad Wildlife Sanctuary, Edakkal Caves, Soochipara Falls, and Chembra Peak. Wayanad is home to several indigenous tribal communities, such as the Paniyas, Kurumas, and Adiyas. These communities have a rich cultural heritage, with traditional practices, rituals, and art forms that are unique to the region. Wayanad has a history that dates back to the Neolithic age, as evidenced by the ancient petroglyphs found in the Edakkal Caves (K. S. Behanan,2004; K. K. Aziz,2007) . The district was also part of the powerful Vijayanagara Empire and later came under the rule of various South Indian dynasties (S. K. R. Seshadri, 2011). However, Wayanad is a district that beautifully blends natural beauty, rich culture, and a sense of history. While it holds great potential for growth, especially in tourism and agriculture, careful management of its natural resources and sustainable development practices are crucial for preserving its unique character.

Wayanad's economy is predominantly agrarian, heavily influenced by plantation agriculture. According to Department of Town and Country Planning, Government of Kerala (2011, January) nearly 40% of the district's 2132 sq. km is forested, with the remaining land divided almost equally between agriculture and plantations. Perennial crops and spices dominate the agricultural landscape, with coffee as the primary crop, covering 66,973 hectares. This represents 33.65% of Wayanad's total cropped area and a substantial 78% of Kerala's coffee cultivation. Other significant crops include pepper, coconut, rubber, areca nut, cardamom, and ginger. Pepper cultivation is concentrated in the northeastern region, particularly in Pulpally and Mullankolly, often intercropped with coffee. Paddy, once a staple crop, has declined significantly, with only a single annual harvest from 12,988 hectares. Much of the former paddy land is now used for banana and ginger cultivation, reflecting recent shifts in agricultural practices. Wayanad lags in industrial development, lacking major industrial units. The existing factories primarily focus on processing tea and coffee, despite the potential for value-added processing of diverse local agricultural products. Animal husbandry, particularly dairy farming, provides a supplementary income source for a considerable portion of the population. The presence of a Kerala Agriculture University veterinary college in Lakkidi further supports this sector.

3.Geographical and Climatic Context of Wayanad landslides

Wayanad, a district nestled within the Western Ghats in Kerala, India, is known for its complex topography and distinct climatic conditions, which play a significant role in its susceptibility to landslides. Geographically, Wayanad is characterized by a series of steep hills, deep valleys, and undulating terrain, with elevations ranging from 700 to 2,100 meters above sea level. The region's geomorphology, largely shaped by tectonic activities and weathering processes, comprises a

variety of soil types, including laterite, clay, and sandy loam, all of which contribute to varying degrees of slope stability (Kumar & Shetty, 2021). The Western Ghats, recognized as a biodiversity hotspot, is also a critical catchment area for several rivers that traverse through Wayanad, including the Kabini, Panamaram, and Mananthavady rivers. These rivers, while vital for the region's agriculture and water supply, also contribute to soil erosion and slope instability, particularly during the monsoon season (Bhattacharya et al., 2019). The district's steep slopes, often exceeding gradients of 30 degrees, combined with fragile soil structures, make it highly prone to landslide occurrences, especially when triggered by external forces like intense rainfall.

Climatically, Wayanad experiences a tropical monsoon climate, with three distinct seasons: summer (March to May), monsoon (June to September), and winter (October to February). The district receives an average annual rainfall of approximately 2,500 mm, with the bulk of this precipitation occurring during the southwest monsoon, between June and September (Kuriakose, Sankar, & Muraleedharan, 2009). This period of heavy rainfall is often characterized by intense and prolonged downpours, which lead to the saturation of soil layers, thereby reducing their shear strength and increasing the likelihood of landslides. The impact of such rainfall is further exacerbated by the region's poor drainage systems, which result in waterlogging and increased hydrostatic pressure on slopes. Moreover, Wayanad's climatic variability, influenced by both global climate change and regional factors, has been observed to intensify the frequency and severity of extreme weather events, including heavy rainfall episodes (Sreekumar, 2020). This heightened climatic unpredictability, coupled with the region's geophysical vulnerabilities, has significantly increased the risk of landslides in recent years.

In addition to natural factors, human-induced changes in land use have also contributed to altering the region's geographical and climatic stability. The deforestation of large tracts of forest land for agriculture, plantation crops, and urbanization has led to the removal of vegetation cover, which is essential for soil cohesion and slope stability (Kumar & Shetty, 2021). Such anthropogenic activities have not only disturbed the natural water flow patterns but have also exacerbated soil erosion and weakened the geological structure of the region, further escalating the risk of landslides.

High intensity rainfall triggers the slope by saturating the overburden and slope materials thereby causing landslides. These areas are covered by very thick layer of overburden material (mainly composed of clay rich lateritic soil). Also the underlying rocks are highly weathered gneissic rocks. The Lateritic soil with higher clay content has high water retention capacity and less water draining capacity; thereby developing high water pressure in the slope material. The Dip-slope relationship of the foliation plane of gneissic rock facilitated the translational (planar) mode of failure of the overlying debris and weathered materials (rocks or boulders). The geographical and climatic context of Wayanad thus presents a complex interplay of natural and human factors, each contributing to the region's heightened vulnerability to landslides. Understanding these factors is crucial for developing effective disaster risk reduction strategies that can mitigate the impact of future landslide events in this ecologically sensitive region.

4.Social and Cultural Context of Wayanad landslides

The social and cultural fabric of Wayanad is deeply intertwined with its natural environment, making the impact of landslides particularly profound on the local communities. Wayanad is home to a diverse population that includes a significant proportion of indigenous tribes, such as the Paniyas, Kurichiyas, and Adiyas, who have historically lived in harmony with the land. These communities rely heavily on agriculture, forestry, and other natural resources for their livelihoods, and their cultural practices are closely linked to the region's forests and biodiversity (Sathyapalan & Iyer, 2019). The occurrence of landslides disrupts this delicate balance, leading to not only economic losses but also cultural dislocation and social instability. The tribal communities in Wayanad have a unique relationship with the land, viewing it as a sacred entity that sustains their way of life. Traditional agricultural practices, such as shifting cultivation, have been practiced for generations and are adapted to the region's ecological conditions. However, the increasing frequency of landslides, exacerbated by deforestation and modern agricultural practices, has threatened these traditional ways of life (Menon, 2020). The destruction of arable land and forest areas by landslides not only undermines food security but also erodes the cultural identity of these indigenous communities, who see the land as central to their existence.

The social impact of landslides in Wayanad extends beyond the immediate loss of life and property. The displacement of communities due to landslides often results in long-term psychological trauma and social fragmentation. For instance, the landslides that occurred in Wayanad during the 2019 monsoon season led to the displacement of thousands of people, many of whom were forced to leave their ancestral homes and move to temporary relief camps (Sreekumar, 2020). The experience of displacement disrupts social networks and community structures that are integral to the cultural and social cohesion of the region. Moreover, the trauma of losing loved ones and the uncertainty of living in disaster-prone areas contribute to long-lasting mental health issues, including anxiety, depression, and post-traumatic stress disorder (PTSD) (Mathew & Sebastian, 2021). The response to landslides in Wayanad is also shaped by social hierarchies and access to resources. Marginalized groups, including the tribal communities and the economically disadvantaged, often have limited access to disaster relief and rehabilitation services. Social inequality exacerbates the vulnerabilities of these groups, making it difficult for them to recover from the impact of landslides (Sathyapalan & Iyer, 2019). Furthermore, the lack of adequate infrastructure and services in remote areas, where many of these communities live, hinders effective disaster response and recovery efforts.

Culturally, the landslides have also led to the erosion of intangible cultural heritage, such as traditional knowledge systems, rituals, and community practices that are closely linked to the land. As landslides destroy sacred groves, traditional agricultural fields, and other culturally significant sites, the communities lose not only their material assets but also their cultural heritage (Menon, 2020). This loss is compounded by the challenges of adapting to new environments and livelihoods, which may not align with the communities' traditional cultural practices. In recent

years, there has been growing recognition of the need to incorporate the social and cultural dimensions of disaster risk reduction in Wayanad. Initiatives that involve local communities in disaster preparedness and response, and that respect and integrate traditional knowledge, are essential for building resilience in these vulnerable populations (Mathew & Sebastian, 2021). Such approaches not only enhance the effectiveness of disaster management but also ensure that cultural heritage and social cohesion are preserved even in the face of natural disasters.

CHAPTER-II

DEVASTATING INCIDENTS OF LANDSLIDES IN WAYANAD

1.Recurring Landslides in Wayanad

Wayanad district in Kerala has a history of landslides due to its location in the Western Ghats, a region prone to heavy monsoon rains, steep slopes, and fragile soil. Over the past two decades, Wayanad district has been plagued by a series of devastating landslides, a recurring tragedy that has inflicted profound human, material, and ecological losses. Since 2007, the region has suffered severe landslides triggered by intense monsoon rains, leading to substantial loss of life, widespread property damage, and environmental degradation. Particularly noteworthy are the catastrophic landslides that occurred in 2017, 2019, and 2024. These events, marked by their intensity and destructive power, have punctuated a chronic cycle of destruction and recovery in Wayanad. This timeline of recurring landslides underscores the urgent need for comprehensive strategies to mitigate the risks and consequences of these natural disasters in the region.

The landslides in Wayanad in 2017, 2019, and 2024 were all caused by heavy monsoon rains, but the scale of destruction and affected areas varied. In 2017, the region experienced isolated landslides in hilly areas, resulting in moderate damage to homes and agricultural land, but fatalities were low. By 2019, the situation had deteriorated, with continuous torrential rains causing major landslides in Mundakkai, Chooralmala, and Noolpuzha. These slides buried entire villages, resulting in significant loss of life and widespread infrastructure damage. More than 200 people had been displaced, and relief efforts were urgently needed.

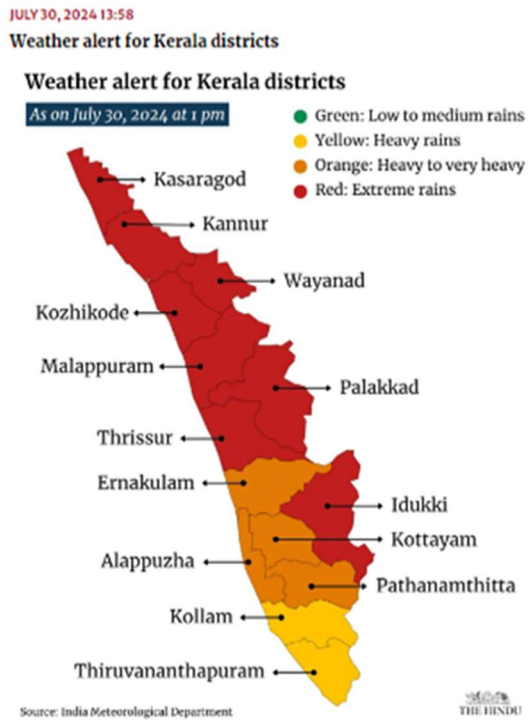
The landslides of 2024, however, were catastrophic. Landslides caused by heavy rains devastated several villages, including Punjirimattom, Meppadi, and Kunhome. Over 442 people were reported dead, with many others injured or missing. Homes were destroyed, roads became impassable, and

large areas of farmland were wiped out. This was the deadliest landslide in Wayanad's history, exacerbated by deforestation and unplanned development. The losses in terms of property, life, and livelihood far exceeded previous years, with rescue operations strained by the magnitude of the disaster.

This is an overview of media reports on the devastating landslides in Wayanad in during the years 2017, 2019, and 2024. The landslides caused extensive damage to homes, infrastructure, and livelihoods. The incidents were linked to heavy monsoon rains, and each one left the region facing enormous challenges, ranging from human displacement to environmental degradation. The reports emphasized the critical need for improved disaster preparedness and sustainable development in the region to mitigate recurring natural disasters.

2.Recent Devastating Incidents of Wayanad landslide in 2024

The Wayanad landslides, which occurred on 30 July 2024 in Kerala, India, were among the deadliest in the state's history. Triggered by heavy rainfall, these landslides struck the villages of Punjirimattom, Mundakkai, Chooralmala, Attamala, Meppadi, and Kunhome, causing extensive destruction. The disaster resulted in at least 427 deaths, over 378 injuries, and more than 130 people missing. The landslides were exacerbated by deforestation, which has significantly reduced the region's forest cover, increasing the vulnerability of the hilly terrain.



Wayanad, part of the Western Ghats, is geologically prone to landslides, especially during monsoons. Studies indicate that deforestation and the creation of plantations have contributed to the instability of these regions. The Geological Survey of India (GSI) confirmed that nearly half of Kerala is landslide-prone, with Wayanad identified as particularly sensitive. Before the landslides, the area received 570 mm of rain in just 48 hours, leading to flash floods and the destruction of villages. Rescue operations were hampered by the collapse of infrastructure, such as the bridge connecting Mundakkai and Attamala. The National Remote Sensing Centre (NRSC) reported that 86,000 square meters of land had moved down the hill due to the landslides. In the aftermath, there was widespread panic due to mysterious rumbling sounds in the area, later attributed to the "Hilling effect," where shifting land masses caused by the landslides created the noise. The region continues to face the threat of further landslides, emphasizing the need for stringent environmental regulations and disaster preparedness in Kerala's hilly districts.

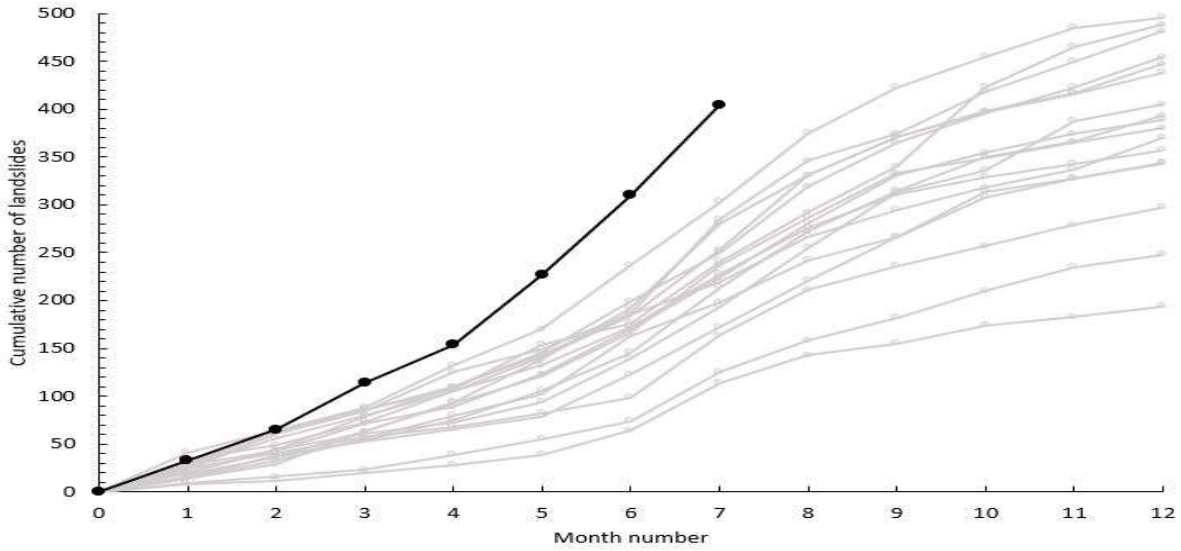
News Clip-1: The landslide Blog

Title: Fatal landslides to the end of July 2024

Date: 13 August 2024

In July 2024, the global trend of high fatal landslide occurrences continued, with a provisional dataset recording 95 events and 1,167 fatalities. This makes July 2024 the second worst month on record, following July 2019, which had 98 events. Notably, the cumulative number of landslides this year has already surpassed the annual totals of all but six years in recorded history, marking 2024 as an extreme outlier.

Two major landslides dominated the fatalities in July: a devastating debris flow on July 30 in Wayanad, Kerala, India, which resulted in around 560 deaths, and a landslide on July 21/22 in Gofa Zone, Ethiopia, causing 257 deaths **(**Petley, D.N. 2012)**.**



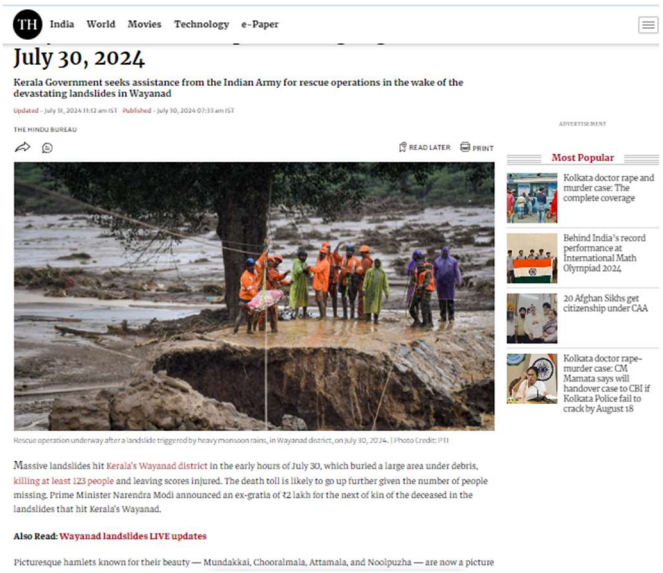
Other significant landslides occurred across South Asia, China, the Philippines, Vietnam, and Kyrgyzstan, with the high incidence likely driven by exceptionally high global surface temperatures and increased rainfall intensity linked to anthropogenic warming and a recent El Niño (Froude, M. and Petley, D.N. 2018). Looking ahead, the threat of further landslides remains, particularly due to tropical cyclones in the North Atlantic and West Pacific, alongside the ongoing monsoon season in South Asia.

News Clip-2: The Hindu Bureau

Title: Wayanad landslides updates: Highlights from July 30, 2024

Date: Updated - July 31, 2024, Published - July 30, 2024

In response to the devastating landslides in Wayanad, Kerala, on July 30, the state government has sought assistance from the Indian Army for rescue operations. The landslides, which buried large areas under debris, have resulted in at least 123 deaths, with many more injured and missing, prompting fears of a rising death toll. Prime Minister Narendra Modi has announced an ex-gratia payment of ₹2 lakh for the families of the deceased.



Picturesque hamlets like Mundakkai, Chooralmala, Attamala, and Noolpuzha, once known for their beauty, are now scenes of destruction and despair, cut off from surrounding areas. Floodwaters have washed away vehicles, which can now be seen lodged in tree trunks and submerged across the region. Rescue efforts are being hampered by heavy rains and massive boulders that have rolled down the hills, but workers continue to brave the conditions, transporting the dead and injured to safety.

The public is urged to provide information to the 24-hour control room, operating under the State police chief, at the following numbers: 9497900402, 0471 2721566.

News Clip-3: The Hindu Bureau

Title: PM Modi Wayanad visit Highlights: PM Modi chairs review meeting at Kalpetta, says funds not a constraint for rehabilitation

Date: Updated - August 10, 2024, Published - August 10, 2024

In a review meeting at the Wayanad Collectorate in Kalpetta, Prime Minister Narendra Modi assured full support from the Centre for relief and rehabilitation efforts in the landslide-hit areas of Wayanad, Kerala. The landslides have claimed 226 lives, with 130 people still missing. Kerala Governor Arif Mohammed Khan, Chief Minister Pinarayi Vijayan, Union Minister Suresh Gopi, and other senior officials were present at the meeting.

The Kerala government expressed hope that the Centre would consider their requests for aid, including a comprehensive reconstruction plan for the affected areas. State Public Works Minister P.A. Mohammed Riyas highlighted Chief Minister Vijayan's emphasis on rebuilding, while Revenue Minister K. Rajan noted the region's ₹1,200 crore loss, with ₹2,000 crore needed for rehabilitation.

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PM Modi Wayanad visit Highlights: PM Modi chairs review meeting at Kalpetta, says funds not a constraint for rehabilitation

Prime Minister Narendra Modi chaired the review meeting to discuss the relief and rehabilitation efforts and interact with survivors at the Wayanad Collectorate at Kalpetta and assured the people of support from the centre

Updated - August 10, 2024 08:07 pm IST Published - August 10, 2024 09:04 am IST

THE HINDU BUREAU

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Kerala CM Pinarayi Vijayan greets PM Narendra Modi before he enters the Air India One flight. | Photo Credit: Special Arrangement

This live blog has been closed.

Prime Minister Narendra Modi said in the review meeting held at the Wayanad Collectorate at Kaleptta that the Centre would provide all the help possible to further the relief and rehabilitation efforts in the landslide-hit areas of Wayanad.

SC/ST Department Minister O.R. Kelu mentioned that the Prime Minister extended his visit to better understand the disaster's magnitude, urging the state to submit a memorandum detailing the losses. The Kerala government has also announced immediate financial aid for affected families.

News Clip-4: The News minutes

Title: Wayanad devastated by three landslides, many dead, hundreds trapped

Date: 30 Jul 2024

The Wayanad district of Kerala has been devastated by three landslides within four hours, severely impacting areas like Meppadi, Chooralmala, Vythiri, and Mundakkai. The rescue efforts face significant challenges as Mundakkai has been cut off from the rest of the district after its only connecting bridge was swept away. So far, 24 bodies have been recovered, with the death toll expected to rise. Health Minister Veena George confirmed 24 deaths in Chooralmala, with 70 others injured. Many homes, known as "layams," where tea estate workers live, were destroyed by the landslides, trapping and killing residents.

The landslides occurred between 2 a.m. and 6 a.m. on July 30, making rescue operations difficult due to destroyed bridges, rain, fog, and strong currents. The National Disaster Response Force (NDRF) is attempting to reach Mundakkai using ropes to cross the river, while additional NDRF teams and Army troops are en route. Residents of neighboring villages have joined rescue efforts, and two IAF helicopters have been deployed. Over 100 people, including tourists, are trapped at the Tree Valley Resort in Mundakkai, and more than 64 injured have been admitted to WIMS Hospital in Meppadi.

News Clip-5: The Sky News

Title: More than 350 people killed in landslides - as experts question tourism's role in tragedy

Date: Sky News, August 2024.

The death toll from the devastating landslides in Wayanad, Kerala, has risen from 93 to 350. Mundakkai, the worst-hit area, has confirmed 205 deaths, with many more missing. The disaster destroyed homes, roads, bridges, and tourist resorts, raising questions about tourism's role in escalating the situation. Wayanad, a popular tourist destination with over 700 resorts, has received warnings about overdevelopment in fragile areas. Experts argue that unchecked tourism and disregard for environmental warnings exacerbated the disaster's scale. The tragedy has prompted calls for more stringent tourism regulations to protect environmentally sensitive areas.

3. Landslide Hazards in 2019

The IPCC Special Report on 'Oceans and Cryosphere in a Changing Climate' (2019) emphasizes that cyclones over the Arabian Sea, even without making landfall, have caused heavy rainfall along India's western coast. With the Indian Ocean, particularly the Arabian Sea, warming rapidly, the frequency of severe cyclones is expected to rise, increasing the chances of future landfalls along India's west coast. Kerala faced its most devastating floods and landslides in 2018 and 2019, which affected millions of people, led to significant casualties, and caused severe economic, social, and infrastructural damage, as reported by the Kerala State Disaster Management Authority.

News Article Clip-1:

India Article in Landslides, September 2020

Title: Causative factors of landslides 2019: case study in Malappuram and Wayanad districts of Kerala

Researcher: Wadhawan, S. K., Singh, B., & Ramesh, M. V.

From August 4 to August 8, 2019, relentless heavy monsoon rains triggered several devastating landslides and floods in Kerala, particularly in the Kavalappara area of Malappuram district and Puthumala in Wayanad district. This paper examines the geological and environmental conditions in these regions to understand the causes of the landslides. Key findings suggest that the main factors behind these landslides were weakened bedrock, erosion, and poor land management. The weakened bedrock, made worse by human activities, lost its stability due to the heavy rains, which were 400% above the normal average. Additionally, streams filled with debris caused massive erosion at the base of slopes. The destruction was further intensified by unscientific slope modifications, poor water management, unplanned housing developments, and the lack of early warning systems. The study highlights the importance of proper land use planning, the need for real-time monitoring systems for floods and landslides, and building resilient communities in landslide-prone areas.

4. Deadly Landslides Cases in 2018

A total of 247 number of landslides recordedin the Wayanad district during 2018. Among thetotal,26 noteworthylandslides were identified using satellite data interpretation, and it noted that the landslides newly occurin this region.

Natural causes influenced by many factors such as rainfall, lithology, structure, geomorphology, drainage, slope, vegetation, soil cover, land cover, and hydrological regime (Mani S &Saranaathan SE., 2017; Reis S, 2008). The present study area is located at high altitude with the rainfed region of Western Ghats in India-Wayanad. The landslide is the leading natural calamity in the study area. Many numbers of landslides identified and recorded in this region during 1978, 1979, 1987, 1993, 1996, 2006, and 2009- this occasion came about numerous casualties and misfortune to properties in Nilgiri regions of Western Ghats (Seshagiri DN, at al.,1982; Balachandran V. et al.,1996). As per the report, there was no landslide during the past three years in this region, In Wayanad, a total of 47 landslides, 45 land subsidence, and 155 landslips were identified during 2018 which quite unusual in this area (District Soil Conservation, 2018).

News Clip-1: India Today

Title: How Wayanad was turned into the land of disasters

Date: August 12, 2024

Wayanad, once a serene region in Kerala, has tragically become a disaster-prone area due to reckless land use changes, quarrying, unregulated tourism, and inadequate disaster management. The recent landslide, claiming 225 lives and leaving over 130 missing, highlights the urgent need for intervention. Indiscriminate human activities, including extensive quarrying and unregulated tourism, have destabilized Wayanad's fragile ecology. The use of mini-excavators in plantations has further reduced soil stability. Climate change, with its extreme weather patterns, has intensified landslides, making Wayanad a high-risk zone. The disaster not only resulted in significant loss of life but also left hundreds homeless. Wayanad's transformation from a tourist destination to a disaster zone is evident, with unchecked growth of resorts and illegal homestays exacerbating the situation.

A comprehensive disaster management strategy is crucial, including relocating residents from high-risk zones, imposing strict land use regulations, and establishing early warning systems. Sustainable development practices must be prioritized to preserve Wayanad's ecology and prevent future calamities. Wayanad's situation underscores the dire consequences of unchecked human activity and policy negligence. Immediate action is required to prevent further devastation and protect the region's future.

News Clip-2: BBC

Title: The scenic Indian villages devastated by deadly landslides

Date: July 31, 2024

On the night of July 31, 2024, devastating landslides struck the picturesque villages of Mundakkai and Chooralmala in Wayanad, Kerala, claiming at least 166 lives, with 192 people still missing. This disaster, the worst since the 2018 floods, has resulted in massive destruction, flattening houses, uprooting trees, and even splitting the Iruvanipuzha river. The landslides caused extensive damage, with rescue operations hampered by heavy rains. The region, part of the ecologically sensitive Western Ghats, has seen 60-70% higher rainfall than usual, exacerbating its vulnerability. The disaster was triggered by extreme rainfall following two weeks of heavy rain, compounded by rapid urbanization and mining. The disaster highlights the neglect of environmental warnings. A 2011 report by ecologist Madhav Gadgil classified Wayanad as a fragile area, recommending a ban on hazardous activities. However, these warnings were ignored in favor of development, leading to deforestation, mining, and unregulated construction. The shift to tourism and construction by plantation owners further weakened the land. The tragic landslides underscore the need for sustainable development and strict enforcement of environmental regulations to prevent future disasters in vulnerable regions like the Western Ghats.

BBC

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The scenic Indian villages devastated by deadly landslides

31 July 2024

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Imran Qureshi

BBC Hindi, Bengaluru

Massive landslides hit Mundakkai and Chooralmala in Wayanad district on Tuesday

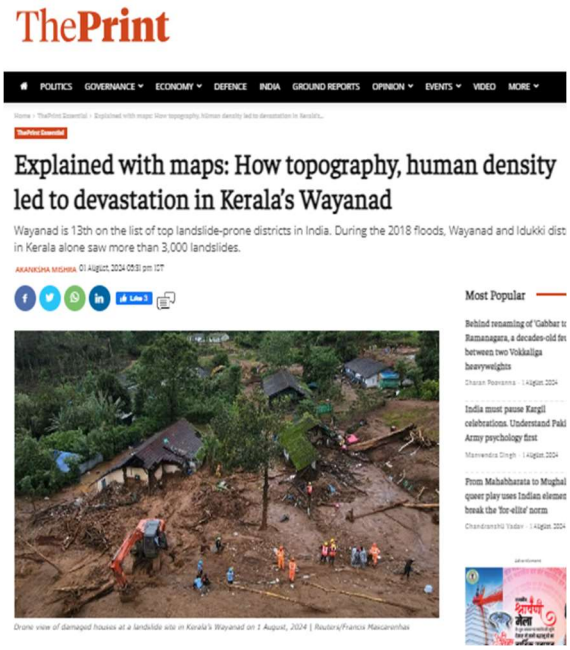
A loud noise shook Ajay Ghosh awake at his home in the southern Indian state of Kerala in the early hours of Tuesday.

At first, the salesman, who lives in Wayanad district's Mundakkai village, did not quite understand what caused the sound.

News Clip-3: The Print

Title: Explained with maps: How topography, human density led to devastation in Kerala's Wayanad
Date: August 1, 2024

Wayanad, Kerala, ranked 13th among India's most landslide prone districts, has faced yet another catastrophic disaster, with Mundakkai at the epicenter. The recent landslides, exacerbated by the district's steep topography and dense population, have claimed 174 lives, with 170 still missing. The steep descent of the Iruvazhinji river from 2,000 meters to 971 meters in Mundakkai significantly increases the force of the monsoon-fed waters, making the area highly susceptible to landslides. This vulnerability is further highlighted by ISRO's 2023 Landslide Atlas, which identifies Wayanad as a high-risk area. The district has a history of frequent landslides, particularly during the monsoon season, with over 3,000 recorded during the 2018 floods. The dense population in steep, unstable areas like Mundakkai increases the risk of casualties during such events. Heavy monsoon rains further exacerbate the situation, creating ideal conditions for landslides. Wayanad's history of recurring landslides, including those during the 2018 floods and 2019 in Puthumala, underscores the region's ongoing vulnerability. The recent landslides in Wayanad emphasize the urgent need for changes in land use and disaster preparedness to mitigate the impact of such natural disasters.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Explained with maps: How topography, human density led to devastation in Kerala's Wayanad

Wayanad is 13th on the list of top landslide-prone districts in India. During the 2018 floods, Wayanad and Idukki dist in Kerala alone saw more than 3,000 landslides.

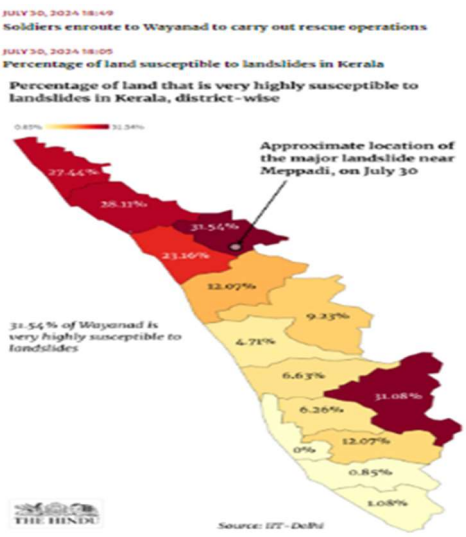
Most Popular

News Clip-4: The News Day

The News Day

Title: Study finds rains that led to deadly Indian landslides were made worse by climate change

Date: August 13, 2024.



A recent World Weather Attribution (WWA) study has confirmed that climate change significantly intensified the heavy rains that caused devastating landslides in Kerala's Wayanad district in late July 2024. The study revealed that the 15 centimeters (5.91 inches) of rainfall on July 29-30 was made 10% more intense due to global warming, contributing to landslides that killed nearly 200 people, with over 130 still missing. The study highlights that human-caused climate change is linked to increased monsoon rain intensity in India, leading to more severe natural disasters. The rainfall was the third-heaviest in Kerala since 1901, reflecting more erratic and intense monsoon patterns due to global warming. Kerala has faced severe floods and landslides in recent years, with past events underscoring its climate vulnerability. Urgent action is needed to reduce deforestation, quarrying, and to improve early warning and evacuation systems. India's high greenhouse gas emissions make it particularly vulnerable, highlighting the need for global efforts to reduce carbon emissions and transition to renewable energy. Scientists Mariam Zachariah and Arpita Mondal stress that as global temperatures rise, extreme weather events will become more common, necessitating immediate action to address climate impacts.

CHAPTER-III

SIGNIFICANT CHALLENGES

The landslides in Wayanad can be attributed to two primary causes natural and anthropogenic factors. Both types of challenges significantly impact the region's stability. On the natural front, factors such as heavy rainfall, geological instability, and soil erosion contribute to the vulnerability of the landscape. Conversely, anthropogenic challenges, including deforestation, unregulated construction, and improper land use, exacerbate the risks. Below is a detailed examination of these challenges, highlighting their individual and combined effects on Wayanad's susceptibility to landslides.

1. Natural Challenges at Wayanad Landslides:

The landslides in Wayanad, Kerala, have been influenced by a complex interplay of natural factors. These problems not only contribute to the occurrence and severity of landslides but also exacerbate the impacts on local ecosystems and communities. Below is an analysis of the key natural problems associated with the Wayanad landslides.

1. Geographical Factors

1.1. Terrain and Topography

Wayanad is characterized by rugged terrain and steep slopes, typical of the Western Ghats region. The steep inclines and high elevation gradients increase the susceptibility to landslides, particularly during heavy rainfall (Kumar & Shetty, 2021). The unstable slopes in this region are prone to failure, especially when exacerbated by intense monsoon rains, leading to significant landslide events. These landslides can result in the loss of land, destruction of infrastructure, and disruption of transportation networks.

1.2. Soil Composition and Geology

The soil in Wayanad is often a mix of laterite and alluvial deposits, which can be prone to erosion and instability when saturated with water (Kuriakose, Sankar, & Muraleedharan, 2009). The underlying geology, which includes fractured rocks and fault lines, also contributes to the instability. The combination of loose, erodible soil and underlying geological weaknesses makes the area highly vulnerable to landslides. This instability can lead to frequent and severe landslides, affecting both human settlements and natural habitats.

1.3. Land Use and Development

Rapid urbanization and agricultural expansion have led to deforestation and land use changes, which exacerbate slope instability (Bhattacharya et al., 2019). The conversion of forested areas to agricultural lands or settlements often involves alterations to natural drainage patterns and soil erosion. The removal of vegetation and alteration of land use contribute to increased runoff and reduced soil stability. This enhances the likelihood of landslides, particularly in areas where soil has been disturbed or where natural drainage systems have been disrupted.

2. Environmental Factors

2.1. Monsoon Rainfall

Wayanad experiences heavy monsoon rains, which contribute significantly to the occurrence of landslides. The intensity and duration of rainfall can saturate the soil, leading to slope failures (Kumar & Shetty, 2021). Prolonged and intense rainfall events can trigger large-scale landslides, which in turn cause damage to infrastructure, displacement of communities, and alteration of river courses. This environmental stress also affects local ecosystems and biodiversity.

2.2. Deforestation and Vegetation Loss

Deforestation for agriculture, logging, and development has led to the loss of natural vegetation that once stabilized the soil through root systems (Menon, 2020). The removal of forests reduces the land's ability to retain moisture and increases runoff. The loss of vegetation contributes to soil erosion and slope instability, making the region more susceptible to landslides. The reduction in forest cover also impacts biodiversity and disrupts local water cycles.

2.3. Soil Erosion and Degradation

Soil erosion, exacerbated by deforestation and unsustainable land management practices, leads to the degradation of soil quality and structure (Kuriakose et al., 2009). Erosion removes the topsoil, which is crucial for vegetation and land stability. Soil erosion reduces the land's ability to support agriculture and increases the risk of landslides by removing the natural soil structure that holds slopes together. This degradation can also affect water quality and availability in the region.

2.4. Climate Change

Climate change is contributing to increased frequency and intensity of extreme weather events, including heavy rainfall and cyclones. These changes exacerbate the risk of landslides by increasing the volume of runoff and soil saturation (Bhattacharya et al., 2019). The enhanced risk of landslides due to climate change leads to more frequent and severe landslide events, which can cause widespread damage to infrastructure, disrupt communities, and impact natural ecosystems.

2. Challenges in the Anthropometric Context

The Wayanad landslides have led to a myriad of anthropometric challenges that exacerbate the difficulties faced by the local communities. These problems include displacement and loss of livelihoods, psychological and social trauma, cultural erosion, social inequality, and challenges in disaster management and recovery. Each of these issues interconnects, contributing to the overall vulnerability of the region's inhabitants.

1. Displacement and Loss of Livelihoods

One of the most immediate and visible problems caused by landslides in Wayanad is the displacement of communities. The landslides have destroyed homes, agricultural lands, and critical infrastructure, forcing thousands of people to abandon their ancestral lands and seek refuge in temporary shelters or relief camps (Sreekumar, 2020). This displacement is particularly devastating for indigenous communities, whose identities and livelihoods are closely tied to their land. For instance, the loss of agricultural land, which forms the backbone of Wayanad's economy, has severely impacted the livelihoods of local farmers, leading to food insecurity and economic instability (Mathew & Sebastian, 2021). For the indigenous tribes, the displacement disrupts their traditional agricultural practices, such as shifting cultivation, which are not easily transferable to new environments. The loss of access to forests, which provide not only food but also materials for traditional crafts and medicines, further undermines their ability to sustain their cultural practices (Menon, 2020). This loss of livelihood forces many to take up menial labor or migrate to urban areas, leading to a dilution of their cultural heritage and way of life.

2. Psychological and Social Trauma

The psychological impact of landslides on the affected populations is profound. Survivors of landslides often experience long-term mental health issues, including anxiety, depression, and post-traumatic stress disorder (PTSD). The trauma of losing loved ones, homes, and livelihoods is compounded by the stress of living in temporary shelters with inadequate resources and uncertain futures (Mathew & Sebastian, 2021). Children, in particular, are vulnerable to the psychological effects of such disasters, which can disrupt their education and development. The social fabric of communities is also strained as families are torn apart, and traditional social networks are disrupted. This erosion of social cohesion can lead to an increase in social tensions and conflicts within displaced communities, particularly in the context of scarce resources and competition for aid (Sathyapalan & Iyer, 2019).

3. Cultural Erosion

Landslides in Wayanad have also led to significant cultural losses. Indigenous tribes and local communities have seen the destruction of sacred groves, traditional agricultural fields, and other culturally significant sites, which are integral to their identities and way of life. The loss of these

sites not only disrupts the transmission of cultural knowledge and practices to future generations but also leads to a sense of cultural dislocation among the affected populations (Menon, 2020). Furthermore, the forced migration of communities to areas with different cultural and environmental contexts poses a challenge to maintaining traditional practices. The shift from traditional agriculture to wage labor or urban occupations can lead to the erosion of traditional skills and knowledge systems, which are essential components of the cultural identity of Wayanad's indigenous tribes (Sreekumar, 2020).

4. Social Inequality

Social inequality exacerbates the impact of landslides in Wayanad, particularly for marginalized groups such as the indigenous tribes and economically disadvantaged populations. These groups often have limited access to resources, including land, education, and healthcare, making them more vulnerable to the effects of natural disasters (Sathyapalan & Iyer, 2019). In the aftermath of landslides, these communities frequently receive less attention and support in terms of disaster relief and rehabilitation efforts. Moreover, the existing social hierarchies and power dynamics can result in unequal distribution of aid, with the more privileged sections of society receiving greater assistance, leaving the marginalized communities to fend for themselves. This inequality not only hinders the recovery process but also deepens the socio-economic divide within the region, perpetuating cycles of poverty and vulnerability (Mathew & Sebastian, 2021).

5. Challenges in Disaster Management and Recovery

The unique social and cultural context of Wayanad presents significant challenges for disaster management and recovery efforts. The region's diverse population, including a large proportion of indigenous tribes, necessitates a culturally sensitive approach to disaster response. However, disaster management strategies often fail to adequately incorporate the traditional knowledge and practices of these communities, which could play a crucial role in building resilience against future disasters (Menon, 2020). Furthermore, the lack of infrastructure and services in remote tribal areas complicates the delivery of aid and the implementation of recovery programs. The logistical challenges of reaching these communities, combined with their social marginalization, often result in delayed or inadequate relief efforts. Additionally, the focus on short-term relief rather than long-term rehabilitation and development exacerbates the vulnerabilities of these communities, leaving them ill-prepared for future landslides (Sathyapalan & Iyer, 2019).

3. Solutions for Wayanad Landslide Management by Holistic Approach

Addressing the challenges posed by landslides in Wayanad requires a comprehensive approach that integrates disaster risk reduction, community engagement, and sustainable development. Strengthening disaster risk reduction frameworks is crucial, combining infrastructure

improvements with early warning systems and sustainable land-use policies to minimize future risks. Equally important is fostering community-based preparedness through regular training, local disaster committees, and simulation drills, empowering residents to respond effectively in emergencies. Recovery efforts must be inclusive, prioritizing marginalized groups and ensuring equitable distribution of resources for housing reconstruction and livelihood restoration. Cultural preservation is also vital; restoring sacred sites and promoting cultural tourism can foster resilience while supporting economic recovery. Mental health support is essential, with services and peer support networks addressing the psychological impacts of landslides. Finally, sustainable development practices, such as agroforestry and organic farming, should be integrated into land-use planning to reduce soil erosion and enhance environmental health. By engaging local communities in conservation and development efforts, Wayanad can build long-term resilience. Together, these solutions form a holistic strategy for managing the impacts of landslides while fostering inclusive recovery, cultural preservation, and sustainable development in this ecologically sensitive region.

CHAPTER-IV

CONCLUSION

The recurring landslides in Wayanad district exemplify a critical intersection of natural and anthropogenic forces, revealing the complex dynamics that exacerbate geohazards in vulnerable regions. As demonstrated through the analysis of landslide events in 2017, 2019, and 2024, the escalating frequency and severity of these disasters underscore an urgent need for a multifaceted approach to disaster management that integrates both environmental and socio-cultural considerations. Wayanad's distinctive geomorphological features, including its steep slopes and fragile soil composition, combined with the high-intensity monsoon rains, create a precarious setting for landslide occurrences. The impact of these natural factors is significantly amplified by human activities, such as deforestation, unplanned urban expansion, and unsustainable agricultural practices. These activities not only destabilize the region's soil and slopes but also erode its natural resilience, making the area increasingly susceptible to landslides. The socio-cultural dimensions of landslide impacts in Wayanad reveal profound disruptions to local communities, particularly indigenous tribes whose traditional lifestyles and cultural practices are intricately linked to the land. The displacement and loss resulting from landslides inflict long-lasting psychological trauma and social fragmentation, further compounded by inadequate access to disaster relief and recovery resources. The erosion of cultural heritage and the disruption of traditional knowledge systems highlight the necessity of incorporating community perspectives and indigenous knowledge into disaster preparedness and response strategies.

To mitigate the risks and impacts of landslides, it is imperative to adopt a holistic approach that encompasses both environmental and socio-cultural dimensions. This approach should involve:

1. Strengthening Early Warning Systems: Implementing advanced Landslide Early Warning Systems (LEWS) and utilizing remote sensing and GIS technologies to enhance predictive capabilities and trigger timely interventions.
2. Promoting Sustainable Land Use Practices: Enforcing regulations to prevent deforestation and land degradation, and encouraging sustainable agricultural and urban planning practices that enhance slope stability and soil cohesion.
3. Enhancing Community Resilience: Integrating local communities, especially indigenous groups, into disaster risk reduction strategies. This includes respecting and incorporating traditional knowledge, providing adequate disaster relief, and supporting community-based resilience-building initiatives.
4. Investing in Infrastructure Improvements: Developing and maintaining robust infrastructure for drainage, slope stabilization, and emergency response to reduce the vulnerability of affected areas and facilitate efficient disaster management.
5. Fostering Interdisciplinary Research: Encouraging collaboration between geologists, climatologists, sociologists, and policy-makers to develop comprehensive strategies that address the multifaceted nature of landslide risks.

By addressing these key areas, Wayanad can build a resilient framework capable of mitigating the adverse effects of landslides and safeguarding its natural and cultural heritage. The integration of scientific insights, community engagement, and sustainable practices will be crucial in transforming Wayanad's approach to disaster management and ensuring a safer, more resilient future for its residents.

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