Journal of Polity & Society (2023) 15(2), 167 - 186

The Future-Oriented Anticipatory Disaster Risk Management – A Case Study in Munnar Gap Road Region

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Kerala floods of 2018 and 2019 educated us on how a climate phenomenon can spiral into a tremendous environmental disaster. The present study has been articulated as a case study that aimed to understand the activities that triggered a series of landslides in the gap road stretch in the Devikulam block of Idukki district in Kerala state, government actions after 2018 for monitoring frequent landslide areas, and the role of systematic risk reduction coordination mechanisms to mitigate future disasters with the support of disaster rebuild strategies. Lack of resilience, a coping mechanism, has changed the community's susceptibility. Frequent landslides in construction areas and awareness of the trade-offs involved in designing sustainable roads in project development must be addressed. The study analyses the priorities and challenges before the government -ranging from lack of political will, poor coordination of government departments, land mafia interrogations, environmental concerns, societal needs, and preferences.

Keywords: Disaster Management, Development Strategy, Anticipatory Approach, Environmental Burden, Monitoring Strategies

Due to its exceptional Geo-climatic (Vergara, Moreiras & Araneo, 2019) context, India has historically been vulnerable to natural disasters (MHA, 2011). Large populations have been affected by disasters caused by biological and hydro-climatic (Gupta Chopde, Singh & Bindal, 2021) outbreaks, which have also resulted in significant death rates. “Of the total geographical area of 329 million hectares (MHA), more than 40 MHA are flood-prone” (NDMA, 2019). Owing to the rise in flood-related damage, there is a cause for concern. Floods affect 75 lakh hectares of land each year on average, destroy 1600 lives, and cost Rs. 1805 crores in terms of damage to public utilities, houses, and crops. (National Disaster Management Authority, n.d.). According to an Indian geological survey, the country’s most flood-prone area covers almost 12.5 per cent of the country. (*Top Ten Flood Prone Areas in India*, 2021) The states that fall within the periphery of India’s flood zones are West Bengal, Orissa, Assam, Bihar, Gujarat, Haryana, and Kerala, which flood their banks, which in turn flood the adjacent areas (Thakur,2018). Natural Disasters have become more frequent since 2018 as climate change and geological change combine in Kerala (National Institute for Transforming India, 2021). Kerala, with a population of 3.5 crores (CAG, 2022), is located between 74° 52' and 77° 22' east longitude and 8° 18' to 12° 48' north latitude. The state of Tamil Nadu borders it on the east, the Arabian Sea on the west, the state of Karnataka on the south, and a geological escarpment known as the

Western Ghats that generally runs northwest to southeast parallel to the shore (National Academy of Sciences, Indian National Acadmy Science & Chinese academy of Acience, 2001).

The state of Kerala is blessed with a variety of distinctive altitudinal variations; three distinct natural regions—the lowlands, the midlands, and the highlands—as well as a vivacious climate, vivacious hydrology, distinctive geological domains and terrains, abundant groundwater resources, ten different types of soil, and a variety of vibrant micro-ecosystems. Changes in cropping patterns, quarrying, slope alterations, soil extraction, conversion of swampy areas, and filling of wetlands are some examples of how land-use changes show themselves. It is critical to protect, develop, and manage land resources based on agroecological and social factors, which calls for resource-based land-use planning for various applications with specific attention to fragile ecosystems, such as paddy fields and highlands (The Kerala State Council for Science, 2007). Natural Disasters have become more frequent after 2018 as climate change and geological change combine. "In 2018, 2515.73 mm (23.34 per cent excess) and 2309.8 mm (12.72 per cent) rainfall were measured in the state in 2019" ("*Kerala Receives Normal Rainfall - The Hindu*," n.d.). The state experienced three disastrous floods between 2018 and 2021, which killed at least 400 people and destroyed thousands of structures (Govt of Kerala, 2019).

This study focused only on the hilly part of the state because it presents unique hydrographical and geographic issues that are not found in the plains. Idukki and Wayanad are the two districts in the state that are most vulnerable to landslides. Landslides have recently destroyed vital infrastructure, ecosystems, and ways of life in these regions, killing a significant number of people (Premlet, 2019). The lack of mainstreaming of risk mitigation strategies, such as land use planning and design alternatives that prevent progress and community infrastructure in areas prone to hazards, was one of the shortfalls observed during the floods. It is critical to mainstream and integrate disaster risk management into various sector development strategies, even though there is an institutional and statutory framework in place for the government to manage disaster response (Govt of Kerala, 2019). To ensure a Climate Resilient Kerala (CRK), all future development planning and operations must consider, an integrated strategy based on the Sustainable Development Goals, Sendai Framework of Disaster Risk Reduction, and the principles of the United Nations Framework for Climate Change (Shradha, Rakesh & Ashna, 2017). Construction operations are currently necessary, but in virtually all instances, effective planning for development and environmental monitoring is absent. This article examines the Gap Road region of the Idukki district in Kerala, which has experienced severe landslides over the past five years and explores the change in rebuilding tactics there. The following two research questions served as the framework for this study

How can reconstruction programs after 2018 be changed from responding to previous landslide events to anticipating approaches that also take subsequent development into account?

To what extent is a discernible shift towards a more unified approach possible to risk reduction with the support of systematic monitoring mechanisms?

The road sector was severely damaged by the 2018 floods, especially in the Idukki district. The road sector has the largest sectoral recovery costs, according to early estimates from the Post-Disaster Needs Assessment Report (PDNA) developed by

the government with the support of the international organization (Kerala State Disaster Management Authority,United Nations Agencies,European Commision & Humanitarian Aid,2018). Landslides, earth slips, debris flows, and rock falls were observed on roads in 12 of the 14 districts in Kerala. To fully recover from floods and improve catastrophe resilience, the government of Kerala realised the need to go beyond traditional techniques of recovery and reconstruction (Govt of Kerala, 2019). There is a critical dilemma regarding highway development on the Munnar Gap road. The issue has worsened because of the mining and leveling of mountains beyond what is permitted. A report submitted by a former Devikulam sub-collector stated that 'unscientific' road widening work and illegal mining led to a series of landslides in the gap road region. (District Administrative Department, 2021). There will be no room for the state to consider the creation of resilient infrastructure because of the overwhelming ecological disruptions occurring in the middle of unsustainable development projects that are rife with ecological degradation. In this study, we will examine the environmental degradation and construction strategies of the government in hilly regions, with special reference to the road widening project on the 41-km-long Munnar-Bodimett stretch that began in 2017 in the Idukki District Kerala (Government of India, 2017). The study can help policymakers at the state level to understand the requirement of systematic monitoring in a dynamic environment of disaster risk in the design and implementation of resilient infrastructure projects and the need for that effort at various levels of government bodies which should be reflected in the policy-making process.

The study examined academic literature on anticipated changes in Idukki's climate and land use. In addition, the study focused on landslide protection measures adopted between 2018 and 2022 in the state that are important to reduce future risks. Only after a severe disaster, do we often look to see what measures our state has taken to recover from disasters and wonder whether we have efficient policies and programs to prevent future disasters. They provide a chance to lower the risks from potential hazards, and the "Build Back Better" strategy used in Kerala's recovery programs following recent major disasters teaches us important lessons about how to approach this stage. The State Government plays an important role in reducing the consequences of disasters like floods. The analysis of our current situation helps to give a clear picture about, what are the lessons attained from the recent disaster that affected our state, and how the state government and the collaborative effort of various authorities' direct scientific developments in landslide susceptible areas. The changing role of government in reconstruction program planning and methods under a varying political and socio-economic system based on recent practices in Kerala in responding to recent floods so should be understood. It is crucial to create a policy that will improve future preparedness while also modernizing the infrastructure and services to improve the quality of life for every Keralite. This includes considering projections of similar disasters.

Review of Literature

Madhav Gadgil in the "Report of the Western Ghats Ecology Expert Panel" states that a "comprehensive monitoring program and network that would involve not only government organizations but also the local community, NGOs, and other organizations, must be immediately designed and operationalized".

R. K Bandari in 'Putting an end to Pedestrian approach to Landslide Disaster

Mitigation in India' tells that "Most landslides are predictable, preventable, and controllable if managed with the proper interventions of Science & Technology, unlike earthquakes and tsunamis, it only takes a strong political and administrative will to put us back on the path to safety".

NITI Aayog (2021) in "Report of the Committee Constituted for the Formulation of Strategy for Flood Management Works in the Entire Country and River Management Activities and Works Related to Border Areas (2021– 26)" states that "the flood in Kerala caused significant damage to about 70 thousand kilometers of road network, and nearly 33 homes were destroyed".

Amit Armstrong, (2013) in "An Integrated Approach to Sustainable Roadside Design and Restoration" explains "the necessity of minimizing effects of site establishment and grading, erosion, dust, noise, and air quality impacts on the roadside environment during construction".

United Nations Secretariat of the International Strategy for Disaster Reduction in "Local Governments and Disaster Risk Reduction Good Practices and Lessons Learned: A contribution to the "Making Cities Resilient" Campaign explains that "local government plays a critical role in the recovery from a disaster, which will continue development once outside supporters have left."

Matija Zorn in the article "Natural Disaster and Less Developed Countries" attempts to explain that "Due to poor infrastructure, a lack of early warning systems, and weak social safety networks, developing countries suffered nearly 90 per cent of disaster-related deaths and 98 per cent of the affected in between 1991 & 2005."

The organization of American States in their report" Landslide Hazard Assessment" defines "what knowledge is required by the Planner when making developments in the landslide area".

The Ministry of Environment and Forests, Government of India in the "Report of the Western Ghats Ecology Expert Panel" states "A thorough monitoring strategy and network must be created immediately. It will involve not just government entities, but also other organizations, universities, non-governmental groups, and even regular people, especially those who reside in and around these places".

The Government of Kerala's "A Resilient Recovery Policy Framework and Action Plan for Shaping Kerala's Resilient, Risk-Informed Development, and Recovery from 2018 Floods Rebuild Kerala Initiative" outlines A novel strategy for rebuilding the State that is more durable, environmentally friendly, inclusive, and vibrant.

Central Water Commission in the report "Kerala Flood Report of 2018" States about "the abnormal rainfall experienced at several places and the data also indicate that the rainfall depths recorded during Aug 2018 were comparable to the severe storm that occurred in the year 1994".

Lalaine M Joya's, and Leodegario De Castro's research associates state in "Disaster Resilience in Housing in the Philippines "states "disaster-resistant homes can save lives, and homes retrofitting particularly for low-income households presents an opportunity to save more lives on a far greater the scale at a much faster pace".

Methodology

This article is the outcome of a qualitative study that brings to bear the road construction on the Gap Road region as a case study to illustrate how 'development

project monitoring' and 'responsible spatial planning' are important to protect local resources. Obtaining a good understanding of the strategies used by the authorities to monitor the project before and after the construction phase in the gap road region required me to spend time in the landslide area. The study set out to determine how different actors relate to different phases of the construction of the infrastructure (road); how they relate to and involve one another.; the structure of national and local resource governance; how certain internal and external actors and circumstances affect resource sustainability; and finally, options for recover from the hazard threats with the least amount of impact on social well-being, the environment, and the economy (United States Environmental Protection Agency, 2016)and how to cope with the consequences (UNDP, n.d.) of the government programs to preserve degraded ecosystems. By dealing with all these components, this study concludes with theoretical and empirical grounds common to vulnerability reduction strategies and adaptive landslide monitoring mechanisms.

Empirical data were collected from August to October 2022 through Field Observation and in-depth Interviews and collected via different kinds of secondary sources, such as publications, reports and newspapers. A thorough literature analysis was integrated with raw data by interviewing key informants and conducting focus-group discussions with some of the communities from Bison Valley, whose 13 acres of a cardamom plantation were destroyed during the landslides, and with communities from Komalikkudy, Societykady, Kakkakada, and Changanacherrykada, who are individuals close to the region, that helped to get an idea about the impact of the landslides and heavy rock blasting for the road widening purpose. The second objective was to present an in-depth description of the opinions and experiences of those involved in the various construction phases in this ecologically sensitive area. This also included asking questions about how to keep risk factors out of areas that are prone to landslides and/or to reduce flood damage, and how environmental harm should be considered in design as integral parts before, during, and after the construction stage. Which organizations and associations should pay sustained attention to when considering institutional reorganisation for responsible and eco-based project implementation?

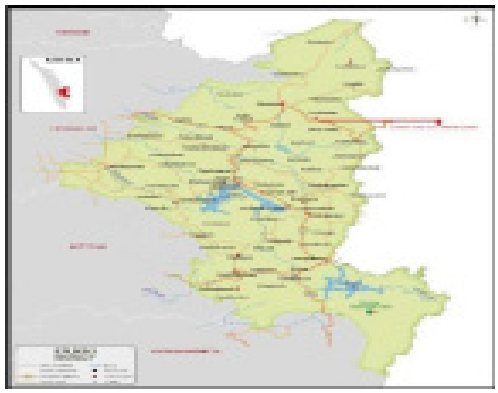
While pertinent information on the entire construction techniques was gathered, discussions with the farmers whose 13 acres of cardamom plantation were destroyed in the crisis allowed for an in-depth analysis of the major difficulties. Using in-depth interviews 20 purposively selected respondents from among the stakeholders including officials from national and regional government, together with other development agencies from various departments were included in the study. The list of respondents in this survey included the district sub-collector, officials from the National Highway Authority, State Highway Authority, officials from the geology department, and officials from the National Institute of Technology-Kozhikode who prepared a report about the landslide in the Gap Road region. These respondents were selected because they have been actively participating in various ways for a long time, indicating that they are likely to be able to deliver the study with a true understanding of the event on the ground and contribute to advantageous recommendations

Figure 1 : Study Area

Source: Idukki District Map (online image). Burning Compass. https://www.burningcompass.com/countries/india/idukki-district-map-hd.html

The gap is a small village or hamlet, part of the Chinnakkanal Panchayath in the Devikulam Block in the Idukki District of Kerala. A heart-shaped crevice between the two mountains forms the name of the location. The original base of the peak was in Bison Valley. The Lockhart Gap region is situated on the Munnar-Madurai National Highway, 13 km from Munnar (Private Tourism Agency, 2011).

At approximately 7200 feet in elevation, it stands out as a distinctive feature of Elevated Mountain. It stood independently and was not connected to any other hills or ranges of hills like the other hill ranges in Idukki. The 167.610-kilometer stretch of road between Munnar and Kundanoor started development in the state primarily with funds allocated by the Government of India (State Planning Board, 2015) as part of the Kochi-Danushkodi National Highway development. This National highway (NH 85), which runs from Munnar to Madurai, begins in Cochin. The major route to Munnar in the Idukki district from surrounding areas, such as Ernakulam and Thekkady, is thought to be between Kochi and Dhanuskodi. Road widening as part of the construction project Kochi – Danushkodi National Highway, a 42-km stretch from



Munnar to Bodimett which falls within the Revenue administration of Udumbanchola/ Devikulam taluk of Idukki District, (Geology Department, 2021) was the primary subject of this study.

Choice of Indicators for Rebuilding the Context, Materials, and Methods.

After the floods of 2018, the government of Kerala realised that the old methodologies were inadequate to save our state from floods; therefore, it is critical to look beyond traditional strategies because only recovery and reconstruction will help us better prepare for disasters in the future. In November 2018, the Rebuild Kerala Initiative (Government of Kerala, n.d.) was launched with a bold vision for a 'Nava Kerala'(Government of Kerala, n.d.) and through it, the state saw a more resilient, green, inclusive, and vibrant future. To achieve that goal, Infrastructure needs to be much more resilient in the upcoming days because Kerala is particularly vulnerable to climate breakdown (Makower, 2019) and environmental disasters and floods are the most frequent among them (World Bank.,IBRD.,IDA,n.d). 'The damage to roads in the flood of 2018, Road damage alone is figured to have cost Rs. 10,000

crores" (Government of Kerala, 2019). From a budgeting perspective, floods have a detrimental effect on revenue generation. Even though Kerala is very susceptible to natural disasters, resilience is not considered in the framework for prioritisation and evaluation, as most of its public investment is allocated to public works. The government's emphasis is on rebuilding a more resilient state, so the current public investment management system (IMF, n.d.) should be upgraded to become more climate-informed (The World Bank, 2015), and the resulting infrastructure will be more resilient in this situation. (Government Of Kerala, 2019). Because site development in hilly areas accounts for 30–40 percent of the total cost of the building complex,(Kumar, 2018) thorough investigations into the type of soil, rock, details of the soil matrix, type of soil strata, the thickness of the overburden, permeability tests in the area to determine drainage conditions, and the area's drainage pattern are required. If necessary, specific slip zones in the area should also be considered. All these parameters should be obtained to identify the type of construction possible in a Specific Zone (BIS, 1995).

According to the rebuilt Kerala initiative, the development program in Kerala for Road network resilience is vital for improved preparedness against natural disasters. To better prepare for both future disasters and fully recover from the current disaster, floods in 2018 sparked efforts to go beyond conventional methods of recovery and reconstruction as a result, A Resilient Recovery (GFDRR, n.d.) Policy Framework and Action Plan for Shaping Kerala's resilience, risk-informed development, (GNDR, n.d.), and recovery have been established. The Rebuild initiative's landslide management strategy states that "it is crucial to establish a coordination mechanism between Local Self Governments, the Soil Conservation Department, the Mining and Geology Department, and the Ground Water Department when planning infrastructure." The Rebuild Kerala Development Program (Government of Kerala, 2019) promotes the use of bioengineering methods to avoid landslides on slopes in construction sites and on infrastructure projects and demands that local self-government should act as the nodal department related to the implementation of the landslide management strategy. In India, all State Highways, Major District Roads, and bridges are planned, prepared for construction, built, maintained, and arranged by the State Highway wing of the department. All planning, project preparation, construction, maintenance, and scheduling for all National Highways and their bridges fall under the purview of the National Highway. Systematic implementation occurs with the help of administrative authorities, including the Chief Engineer, the Deputy Chief Engineer Administration, the Senior Administrative Officer, Administrative Assistant (General), and the Administrative Assistant (Ministerial), with the necessary complement of subordinate staff (Indian Standards, 1995). The Chief Engineer oversees and is accountable for the effective operation of each branch of the department, as well as its administrative and professional head. The Chief Engineer under the management of the administration is responsible for issues involving the interpretation or modification of current policies and procedures. In consultation with the relevant Chief Engineers or in accordance with the decision of the Chief Engineers Committee, he shall issue, modify, or revise circulars relevant to all branches (Cochin Development Authority, 2012). An important question is how scientific developments in hilly regions are not possible, even though the responsibilities are clearly defined.

Case Study Based on the Rebuild Context

The case study has been articulated in the hilly region of Idukki district in Kerala, which is located among the Cardamom Hills of the Western Ghats. Kattappana and Thodupuzha are the two municipal towns in the Idukki district. Currently, there are five taluks in the district (Govt of Kerala, n.d.). The western flank of the Western Ghats, which spans the eastern part of Kerala, constitutes one of the most landslide-prone areas in India (Kuriakose et al., 2009). Climate change, unsustainable resource use, a lack of disastrous events risk awareness, poor hazard-spotting infrastructure provided by national protocols and central agencies, and slow implementation of civil defense all contribute to growing vulnerabilities. The high levels of disaster risk in Kerala are supported by the lack of appraisal of disaster risk across the economic and social sectors because of several competing demands on limited financial resources states the 2018 report of the State Disaster Management Authority (IPCC, 2018). Idukki experienced a total of 143 landslides, of which almost 100 can be classified as road slips, as they occur mainly due to a lack of scientific design in the construction of roads. The indiscriminate construction of hilly roads and infrastructure by cutting and leveling slopes are rampant in the highlands of the state (RGIDS, 2018).

The stretch of roadwork on Munnar-Bodimett in the Idukki District began in 2017(Government of India, 2017). However, floods and landslides from 2018 to 2021 in Kerala have caused to suffer unexpected losses. Each of these major and minor landslides was observed on the Munnar-Bodimett gap road. The serial landslides in this region are linked to a climate-change and to the road-widening project that started in 2017(Vellaram, 2019). According to the District Geological Department officials, road widening is being conducted in an unscientific manner (Geology Department, 2021). Also, the district collector informed the Revenue Principal Secretary of the state about the condition of the Gap Road region in the report “Independent Response submitted by the Sub-Collector” (Government, 2021). The possibility of landslides in the area was also mentioned in that report. The earthmoving that was done as part of the road widening project was done without building retaining walls on the slopes on the side of the road, which posed a risk and could cause more landslides (Government, 2021). The report “Independent Response submitted by the Sub Collector” recommended that road widening initiatives in the specific area should be carried out only after conducting a detailed study by a professional agency. In 2020, nearly 200 m of the road was washed away, as well as more than 13 acres of cardamon plantation in the landslide happened in the gap road region. After this crisis, officials constructed a retaining wall to prevent landslides in this region. Retaining walls are required in areas where additional support is required to prevent the Earth from sliding downhill (Geo Forward, 2020). An existing circular state in which an environmental feasibility study is not necessary for road development of less than 100 km (Government of India, 2015), and the gap region is an environmentally fragile area; however, a feasibility study was not conducted before the construction started and officials were not bothered about the mitigation measures needed for that fragile region. But after the series of landslides the National Institute of Technology, Kozhikode, researched landslides that had been observed in the vicinity and found that the rock is positioned on a slope in various strata with sufficient faults and cleavages in that region. The use of explosives splits the rocks,

allowing water to pass through, causing the rocks to doze off, and causing traffic accidents (Times of India, 2023). Therefore, it is essential to identify tasks, duties, and deadlines during the construction process and track them throughout the operation. It is also important to gather comprehensive data to comprehend the advantages and disadvantages of various sustainability strategies that help choose the most suitable strategies during the construction process in the hilly region. The application of sustainable best practices should be sufficiently adaptable to be updated throughout the operations (Armstrong., Sousa., Ap., Brinckerhoff., Haggerty., Fischer & Wagenlander, 2010) All these would have been possible through necessary monitoring.

Importance of Sustained Landslide Monitoring System: Conceptual Foundation

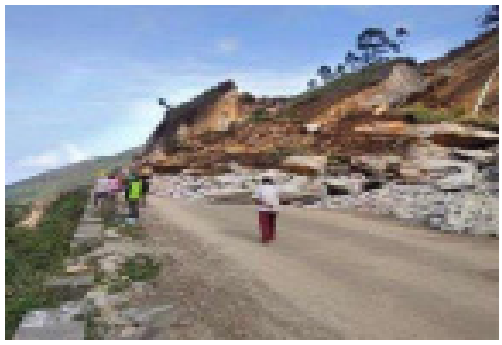
The theory of sustainable development emerged in the 1980s, emphasizing the integrated development of the environment, society, and economy (Shi et al., 2019). Dernbach (2003) states that "to make sustainable development operational, it is necessary to understand that integrated decision-making will guarantee environmental goals and considerations are integrated into development decision-making processes, rather than being handled separately or independently. Among the concepts found in the framework for sustainable development, integrated decision-making is arguably the one that may be most readily incorporated into legislation and policy instruments". Theoretically, all hill slopes are sensitive to mass movements (Schmidt, 2001) based on denudation operations, human actions, and triggering mechanisms (NDMA, 2019). The theory of sustainable development is most suitable for analyzing how important the integration of environmental goals and their considerations into development decision-making processes. Hence, decision-making fragmentation must end for sustainable development to occur—that is, environmental and social issues must be incorporated into decisions about the economy and security (Dernbach, 2003).

As the World Bank (2015) mentioned earlier, "Kerala is very susceptible to natural disasters and resilience is not considered in the framework for prioritization and evaluation, as most of its public investment is allocated to public works". The series of landslides that happened in the Gap Road region tells the importance of Disaster Resilience. Theoretically, Disaster resilience is the capacity of a society, community, or system to withstand a disaster, recover with the least amount of damage, and maintain equilibrium in terms of its social, physical, and psychological components(Karpysynda., Direnclilidi., Varol & Kirikkaya, 2017; Mehmet, 2021). The widespread property loss caused by the recent landslide in Kerala has revealed that most construction strategies are ill-conceived and do not adhere to standard conditions. Government departments do not generally adhere to design codes. This has resulted in an alarming situation in which a substantial amount of unsound building stock is added to the existing enormous number of potentially hazardous structures in hostile environments, vulnerable habitats, and unstable hilly and tectonically active terrains. This is where the significance of Godschalk's statement becomes clear; Godschalk (2003) stated that "risk reduction and resilience cannot be considered separately. Predicting hazards, keeping an eye on them, and reducing or eliminating their impacts are all examples of systematic steps performed to lower risk. To safeguard individuals and property from dangers and their consequences,

sophisticated steps are implemented throughout the risk-reduction phase to minimize, mitigate, or eliminate risks"(Mehmet, 2021). Unplanned development activities in the mountains include large investments, lack of drainage, and non-technical roads in remote areas, which aggravate and worsen the situation. Serial landslides in the Munnar Gap Road region because of the road widening project that began in 2017 continued until 2022. The study and pictures show that 90 per cent of the road development has been completed in 2022, and the retaining wall for the safety of the region has been built after these series of landslides, which will not reduce the future risk completely. This region is the best example of unplanned development activities in the hilly region. Two dozen major landslides occurred on the Gap Road Stretch because of unscientific road widening work (Times of India, 2020), which opened the eyes of the authorities that disclosed the way to construct the retaining wall in 2020.

A National Land Use Policy (NLP) has already been established for the country and was updated in 2013. However, in the 2013 National Land Policy, there was no specific mention of any land use policy for the Indian Hill Region and Western Ghats. Because mitigating and reclaiming landslides and slope instability is more difficult and expensive, it is preferable to prevent them. (NDMA, 2019). Neither the Department of the Government of India nor the Ministry established a project (Pal & Sha, 2018) to train experts, such as civil engineers (ASCE, n.d.), geologists, geotechnical engineers (TWI, n.d.), disaster managers, and trainers for landslide mitigation and management, in cooperation with other national and international agencies using cutting-edge techniques. (NDMA,2019). The Geological Survey of India (GSI), the country's central agency (nodal agency) for (Sajinkmar., Anbazhagam., Rani & Muraleedharan, 2014) landslides, has mainly conducted research and analysis on landslides in various states, and then there are some pieces of training for geologists on landslide investigation and studies, Landslide Hazard

Figure 2 : Munnar Bodimet Gap Road Region during road construction

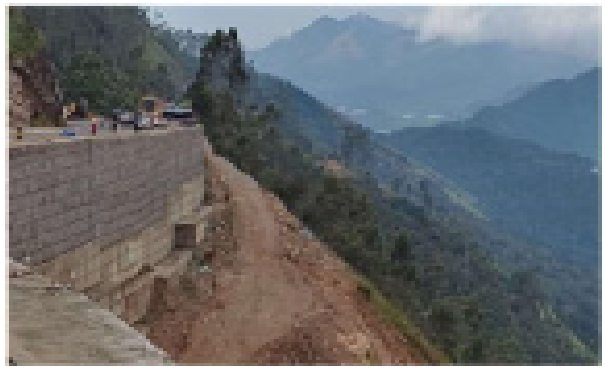


The Hindu (2019, July 29). (https://www.thehindu.com/news/national/kerala/landslip-stops-traffic-on-nh-near-munnar/article28743472.ece/amp/)

Figure 3 : Munnar Bodimet Gap Road Region 2022

(Photograph taken by author)

Figure 4: Retaining wall constructed in Munnar Bodimet Gap Road after series of landslides 2022



(Photograph taken by author)

Zonation mapping, and more. It is almost always up to the state governments to develop and implement mitigation projects (NDMA, 2019).

Landslide Vulnerability Reduction Strategies

Strategies for reducing vulnerabilities related to construction in the hilly region are designed to keep risk factors out of areas that are prone to landslides and/or to reduce the flood damage that risk factors sustain. The study distinguishes the following strategies with regard to land development restrictions and building regulations:

Land development restriction

This includes land-use classification, land-use zoning regulations, and development promotion/control regulations (Govt of India, 2019). The basic goal of land-use zoning is to establish rules for the advancement of an area so that it can serve a specified purpose effectively and maintain its character (Govt of Kerala, 2018). Such regulations primarily aim to improve people's standard of life by sorting proper land advancement or development in compliance with developmental policies and the proposals therein for land use. The main goal of these regulations is to specify the scope of construction and the existing placement of the structure within diverse use zones for (Govt of India, 2019) upcoming activities (Deborah, 2001).

Building regulation

A set of rules that are enforced in human settlements are known as building regulations to preserve the environment, public health, and safety. The government or development authority can use these measures to control the use of appropriate, buildings, infrastructural elements, and land resources to maintain adequate spatial organization and environmentally friendly practices in the city. They also provide critical setup and statutory restrictions on the designing, planning, and construction of structures and related works,(Kumar & Pushplata, 2015) taking measures to render potentially hazardous structures safe and establishing provisions for enforcement and granting authority concerns (Kumar & Pushplata, 2015). By regulating the

appropriate development of land that is consistent with the developmental goals and the land use proposals contained therein (development promotion regulation), such regulations (Govt of India, 2019) primarily aim to improve the quality of life of people (BMTPC, n.d.). Construction and development projects are being carried out in densely populated areas with high, unstable slopes, more than 35 and up to 60 percent ground coverage without trees or greenery, and with limited natural light, air, and ventilation can be avoided. Because construction in these conditions can cause environmental chaos and negatively impact human health and well-being (Kumar & Pushplata,2015). The designated use zones and use premises are covered by the development promotion regulations. Under the State Government's (urban/ special area) planning legislation, development promotion/control regulations are typically included in the development plan. (Deborah, 2001).

Landslide Defense and Monitoring

All current and future development initiatives involve landslip risk assessment, project development, and remedial actions to avoid construction, apparent, or anticipated slope failures (LRRB, 2018) and environmental harm should be considered in design as integral parts before, during, and after the construction stage (Bandari,2015). All landslide-prone states should conduct a comprehensive training needs assessment at the national, state, district, tehsil, block, and village levels in the administrative hierarchy. Unique training modules (National Legal Service Authority, n.d.) should be built for each level and the frequency of training should be figured out in each region as part of a capacity-building action plan (KSDMA, 2021). All landslide-prone states should conduct a thorough assessment of their training needs at the national, state, district, tehsil, block, and village levels of the administrative hierarchy. As part of a capacity-building action plan, distinct training modules should be created for each level and the frequency of training in each region should be specified (NDMA, 2019) This change in the direction of integrated landslip risk management is mirrored in land-use rebuilding programs at many different levels. (Nordbeck et al., 2019) Even though the state government opted not to regulate land development, the KSDMA's non-binding policy documents on spatial planning, which also include policy recommendations for those who make decisions in the state, deal with the implications of spatial planning for landslides/floods, and support municipal and provincial spatial planning, are some of the various safeguards for building more resilient structures, (Nordbeck., Steurer & Loschner,2019) are some of the various safeguards for building more resilient structures. In terms of land use and spatial planning, Kerala's flood policy has undergone a fundamental change because of the recommendations made by the Kerala State Disaster Management Authority on natural hazards. The first planning document for hazards merely emphasized the scarcity of hazard data and the vital requirement for improved consideration of hazards caused by nature in spatial planning (Nordbeck., Steurer & Loschner,2019). Following the extreme events of 2018, policy recommendations were created to strengthen the function of spatial planning in risk mitigation and landside prevention. The most recent document promotes a more risk-oriented approach to spatial planning and acknowledges the significance of national progress in land use regulation. Establishing risk reduction as a primary concern for spatial planning at the state level, the redevelopment of zoning limitations for constructing land in hazardous areas is an effective technique to mitigate increases in flood (Nordbeck.,

Steurer & Loschner, 2019) and landslip damage (Organization of American States, n.d.).

Study results

The region around Gap Road (Gap is a small village or hamlet, which is a part of the Chinnakkanal Panchayath in the Devikulam Block in the Idukki District of Kerala) is seriously dangerous. Road widening projects in the area were completed without performing a comprehensive study by an expert organisation. More rocks were forcibly removed from the side of the road in the vicinity of the Gap Road by the contractor company. The construction of retaining walls (Legal Service Commission, n.d.) for the hills on the side of the road was not done as part of the road widening project, which put the public at risk and contributed to future landslides. According to research conducted by the National Institute of Technology, Kozhikode, into landslides that had been observed in the vicinity, the rock is positioned on a slope in various strata with sufficient faults and cleavages in that region. The use of explosives splits the rocks, allowing water to pass through, causing the rocks to doze off, and causing traffic accidents. After a series of landslides from 2018 to 2021, a protective wall was built, and the retaining wall construction is a good illustration of a successful decentralized disaster management strategy in this hilly region. To avoid or minimize the negative environmental effects of the proposed activity, adequate mitigation measures must be implemented during the project's construction and operation phases; however, this is not the main agenda for most of the projects which will affect both the environment and the construction project itself. People's interests, both in the short and long term, must frequently be kept as a guiding factor in planning and pricing. Many post-disaster reconstruction situations attempt to duplicate the way things were before because they are rushed and must be completed quickly. Future and current environmental needs must be considered during the reconstruction process. In addition, there is evidence that Kerala is lagging in considering these needs. In addition to disaster mitigation and economic and human sustainability, a rapid reversal of this trend is necessary.

Rebuild Kerala Initiative (Government of Kerala, n.d.) developed by the government of Kerala after the flood and landslides of 2018, supported by the World Bank, enhances the task of rebuilding to prepare for potential future disasters by considering threats brought on by climate change and natural disasters such as floods. According to the Post-disaster Need Assessment developed by international development partners like the World Bank and the European Union (Walia., Sharma & Nusrat,2022) to support the rebuilding initiative, road construction is thought to be the main cause of hundreds of landslides, and existing roads increase the risk of landslides. Therefore, it is recommended that on slopes of more than 22 degrees, road construction as well as other human activities should be avoided, and a review of road systems by geologists and hydrologists is necessary for an eco-safe road construction methodology to be used. The rebuilding initiative has increased the need for a more comprehensive and integrated conceptualization of the transition to climate-resilient structures. However, on-site observations of the study revealed that more coordinated efforts are needed to encourage this transition because current efforts to implement rebuild initiatives and build the knowledge base are accelerating but are still fragmented and frequently sectorial in nature, especially since state government officials are not properly communicating regional rebuild strategies

with other departments such as National Highway Authorities.

Stakeholder Perceptions Regarding Landslides and Road Construction

This section presents some of the major perspectives of the stakeholders interviewed in this study. Such impressions are consistent with the outcomes of the literature review and direct observations made during the study. The investigator began the interviews by asking and affirming whether the interviewees were aware of the root cause of landslides in the study area. Almost all the 20 respondents (98.3 per cent) indicated that they were aware. Again, the interviewees were asked whether there were any currently existing mechanisms to decrease future vulnerability, which is a byproduct of the construction project. A total of 95.7 per cent of the respondents indicated that they were planning to implement a technique for a Landslide Monitoring System (LMS), which will be a useful tool for identifying landslide threats in hilly terrains. However, they also pointed out that the retaining wall may be effectively utilized to tackle the problem of landslides in hilly areas by stabilizing the fill slopes and cut slopes that had been constructed after this series of landslides. These responses show that various kinds of governance-related factors contribute to environmental degradation. When asked to indicate the key factors responsible for denying the proper implementation of policies with sound environmental issues or stopping the weakening of the environment, 96.7 per cent of the respondents stated that the fundamental cause is a lack of political will and land mafia support, which results in poor coordination across government departments for the implementation of environmental legislation. There has also been compliance between a society's immediate needs and the short-term interests of the government since they did not connect environmental concerns, attitudes, and preferences to actual activities.

Community's Perceptions regarding Landslides and Construction in the Gap Road Region

Some of the key opinions of the community group, farmers who grew cardamom in the gap region, interviewed for the study are included in this section. The results of the literature review and the specific observations obtained throughout the investigation concur with these perceptions. The investigator began the interviews by determining whether anthropogenic influences played a role in the region around the increased vulnerability of the gap road. From a total of 20 respondents, nearly all (98.3 per cent) stated that the lack of proper rock stability analysis before the beginning of the construction is the reason why the enlargement of the road becomes problematic in this area. Additionally, the former Devikulam sub-collector produced a report outlining the environmental damage, but the national highway authorities did not consider this. The contract for the Munnar-Bodimet National Highway was awarded to Ahmedabad, Gujarat-based private limited company, Dinesh Chandra R. Agrawal Infracon Private Limited and Green-worth infrastructures were the subcontractors. According to locals, the Shathanpara police filed an FIR and, after conducting a preliminary inquiry, discovered that over 50,000 loads of rock had been illegally crushed which had increased the vulnerability of the studied region.

Institutional Dimensions of Environmental Management and Road Infrastructure Development in the Hilly Region

Every project is different in terms of environmental conditions. To recognize the necessity and urgency of ecological conservation, it is necessary to reform existing legislation with updated facts. Although an existing circular state in which an environmental feasibility study is not necessary for road development of less than 100 km, it should have been done before construction started, considering that it is in an environmentally fragile area. The process of developing policy is impacted by the trivialization of climate mitigation initiatives at different levels of government agencies. Higher research, education, the building of capacities, and training are required to fill these gaps, and knowledge-gathering and knowledge-transfer activities must be planned and given higher priority. The implementation of road projects is subject to several legislative requirements. Therefore, everyone involved should be informed of the current environmental and social laws that apply to the construction and operation of road projects.

Discussion

To recover from the 2018 floods and increase resilience to future disasters, the Kerala government recognized the need to go beyond conventional approaches to recovery and reconstruction. However, cost-benefit analyses overlook essential factors affecting project profitability and risks. Additionally, unethical behavior can produce perverse incentives for destructive projects, rewarding decision-makers who approve new roads despite unfavorable (Alamgir et al., 2017) circumstances. It has been confirmed that the Rebuild Kerala initiative is a good compass for resilience. Integrating effective monitoring mechanisms to increase resilience in construction projects is necessary. However, a good map like RKI alone does not help if there is no movement toward the goals. This article has spelled out that avoiding unsustainable practices in all essential operations in ecologically sensitive areas, examining different stages of implementation, and incorporating them into law and the budget continue to be complex tasks in the present scenario. The article draws heavily on the fact that reforms may not achieve their intended goals if they lack assistance from a network of partners on both a high political and technical level. It is important to obtain and not take this assistance for granted. When government agencies cooperate, the results of their policy efforts will increase tremendously; for example, the exchange of information and cooperation between the National or State highway authority, Disaster management authority, and Geology Department will be the most solid methodology to assess the effects of resilient infrastructure outcomes in the hill region. For the effective formulation of public policies and programs, it is necessary for concerned public officials and employees, as well as other stakeholders, to participate appropriately. External organizations must also participate in monitoring operational efficiency, and public service users must provide feedback to assess the accessibility and quality of the services. Finally, accountability is crucial for both the use of public funds and the outcomes of their use.

Conclusion

The gap is a small village or hamlet, which is part of the Chinnakkanal Panchayath in Devikulam Block in the Idukki District of Kerala. There is a critical dilemma with the highway development at the Munnar Gap road. During heavy rain, the area has seen about 13 significant mudslides and landslips from 2017 to 2021. Although most of the part of the road was of standard width, the rocky spots were widened more for

the road construction, which started in 2017. The road's alignment was set at 7.5 meters on either side of the center, but it was discovered that the width had exceeded that distance from the center in many places. A total of about 2.51 lakh cubic meters of rock, or 6.28 lakh metric tons, had been illegally extracted, according to the committee, which includes the Sub Collector of Devikulam and representatives of the Pollution Control Board and Department of Mining and Geology that had appointed by the National Green Tribunal to investigate claims of unauthorized quarrying. The committee found that unscientific road-widening projects along the gap region have caused this crisis. Multiple locations experienced simultaneous rock blasting, shaking the rocks' weak layers, and resulting in landslides. Rocks, soil, and other detritus make up slopes. When the force of gravity, which is influenced by slope angle, climate, slope material, and water, pushes these materials downward more than it is resisted by the material's shear strength, cohesion, and internal friction causing instability and causing the materials to loosen. The slopes become progressively unstable because of constant horizontal vibrations caused by blasting or excavation during construction. A protective wall was built in this region after a series of landslides from 2018 to 2021. The retaining wall support erected area in the gap road stretch from Munnar to Bodimett supports the assertion that district policymakers and officials have enough incentives to innovate, which is a good illustration of a successful decentralized disaster management strategy. The committee, appointed by the National Green Tribunal, decided on environmental damage compensation by estimating the price of the illegally extracted mineral. However, the environmental damage cannot simply be compensated for by compensation. To avoid or minimize adverse environmental effects caused by the proposed activity, adequate mitigation measures must be implemented during the project's construction and operation phases.

By thoroughly assessing the proposed project's environmental effects before taking any further action, the environmental impact assessment intends to give the environment its proper position in the decision-making process. Highway authorities must have a staff person assigned explicitly to environmental issues and knowledgeable about environmental laws and regulations. The Gap Road stretch has experienced more than a dozen significant landslides over the last three years. However, the administration failed to lessen the effects of landslides through better spatial design during the project's construction and operation phases. Planning for development is a creative process that calls for a thorough evaluation of the current situation and the provision of possibilities for sustainable development within the constraints of demographic, physical, socioeconomic, jurisdictional, and financial factors. Ecosystems in hilly locations are delicate and must be protected. Also, development and planning approaches for hilly areas must be created with more care and effective land-use planning.

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