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EXPLORING THE RELATIONSHIP BETWEEN SOCIO–ECONOMIC DYNAMICS AND LANDSLIDES: THE ROLE OF TRADITIONAL KNOWLEDGE (TK) IN KOTHMALE COMMUNITIES, SRI LANKA

Chethana YGJ*

Department of Indigenous Social Sciences,
Faculty of Indigenous Social Sciences and Management Studies,
Gampaha Wickramarachchi University of Indigenous Medicine, Sri Lanka

Abstract: Landslides are severe human-caused climate-related disasters relevant to Kothmale. Although precipitation and steep slopes are the main causes of landslides in Kothmale, the frequency and impact of these events in this area are a reflection of long-term socio- economic dynamics. This research explored the two-way relationship between socio - economic dynamics and landslides in Kothmale with special focus on the role of traditional knowledge in landslide disasters. This research uses a qualitative research strategy, and the thematic analysis focuses on investigating the connection between landslide vulnerability, socioeconomic factors, and the traditional knowledge in disaster risk management. The results reveal that socioeconomic vulnerability raised the intensity and frequency of landslides in Kothmale. Furthermore, traditional knowledge promotes socioeconomic resilience. But a clear knowledge gap was identified between younger and older generations regarding disaster-related traditional knowledge. Hence, this study recommended documenting traditional knowledge and encouraging its transmission to future generations. That contributed to promoting Sustainable Community-Based Landslide Risk Management in Kothmale.

Keywords: landslide, Kothmale, socio-economic dynamics, traditional knowledge, sustainable community-based landslide risk management

Introduction

Landslides have become one of the most significant and prevalent human-caused climate-related hazards, especially in the steep, mountainous regions of the central highlands of Sri Lanka. According to Selvaraj and Nishikawa (2019), 38% of Sri Lanka's population lived in places that are vulnerable to landslide disasters, which account nearly 30% of the country's land area. Since ancient times, Kothmale has experienced landslide disasters. According to the recorded historical documents and oral traditions, notable mass movements occurred in 1933, 1947, 1957, 1958, 1970 and 1979 (Bandara, 2013). The significant occurrences, like the 1947 flood and landslide disaster situation, pushed local residents to relocate to safer areas (Senevirathna, 2001). For instance, an investigation carried out in 1979 and 1980 documented over 300 mass movements in the Kothmale. It indicates that the entire region is extremely

*Corresponding author's email: jayanichethana469@gmail.com

vulnerable to landslide disasters (Johansson, 1989). In the recent past, Kothmale has still been impacted by landslides. On 25th September 2015, a deadly landslide situation occurred at Lilisland in Wedamulla Estate, killing 07 persons (Handa et al., 2018). According to the Cyclone Ditva Disaster Incident Report at Kothmale East Divisional Secretariat Division (2025), the Ditwa Cyclone, more recently, caused 32 deaths and left 20 missing. It emphasizes the region's susceptibility to climate-related risks. The massive landslide that struck Kothmale on 27th November 2025 is a warning of the ongoing vulnerability of central highland villages to frequent landslide hazards.

Even though precipitation and steep slopes are the main causes of landslides in Kothmale, the frequency and impact of these events in this area are a reflection of long-term social dynamics. Such as population expansions and land use change, colonial impact etc. In addition to these societal aspects, Kothmale's vulnerability to landslides is further reinforced by economic situations. In that case, this study highlighted that development and relocation efforts, monoculture plantations, poverty increases exposure and long-term effects on landslide disaster (Senadheera, 2026). As a result, landslides in Kothmale are the result of two -way relationship between social and economic factors rather than just being physical occurrences. It contributed to explain landslide disaster in Kothmale in a contextual manner.

There is increasing recognition that integrating traditional knowledge with contemporary DRM is necessary to improve the resilience of hazard-prone areas. Research suggests that successful disaster risk reduction, particularly in rural and environmentally vulnerable areas, requires integrating scientific information with TK systems (Mercer et al., 2010; Hiwasaki et al., 2014). Most of the Sri Lankan local communities depend on ecological warning signals for detecting natural disasters (Dasanayake and Matsuda, 2019). When considering Kothmale communities' traditional knowledge was a locally created framework of environmental awareness that has formed over time as a result of long – term interactions with their mountain surroundings. In the case of landslides in Kothmale, community members identified several types of early warning signs and followed traditional slope management practices. This research reflected the historical contributions of traditional land–use practices to terrain stability and soil conservation. But the results reveal a clear knowledge gap between younger and older generations regarding the transition of disaster-related traditional knowledge.

According to studies on soil erosion and landslide frequency, accelerated land-use change, plantation expansion, and the elimination of forests dramatically boost the risk of slope instability (Senanayake et al., 2020). Although these studies offer useful technological and context-sensing-based insights, they frequently give environmental indicators priority over experiences at the regional level. As a result, less

qualitative research has been done on the socioeconomic factors that influence land-use decisions, such as poverty and development programs.

In addition, studies carried out in Sri Lanka's hill country demonstrate the growing impact of extreme rainfall patterns and climate variability on the occurrence of landslides (De Silva & Sonnadara, 2009). Climate change is highlighted in these studies as one of the main trigger causes of landslides in mountainous areas. However, real-world data from areas like Sabaragamuwa and Aranayake show that socioeconomic vulnerability and pre-existing environmental damage combine with extreme weather events (Perera et al., 2018; Senanayake et al., 2020). All of these results point to the interconnected meteorological, ecological, and socioeconomic factors that cause landslides in Sri Lanka's central highlands. However, rather than carrying out in-depth, qualitative, community-based research in particular places, the majority of studies concentrate on more general provincial or national-level evaluations.

The majority of the literature addresses these aspects independently, focusing on typical modification techniques, socioeconomic effects, or geophysical analysis. There is still a lack of integration of research that looks at both the changing importance of traditional knowledge in a particular community setting and how socioeconomic variables affect landslide risk.

Materials and Methods

This research follows a constructivist ontological viewpoint. It emphasizes the landslide risk is seen as a socially associated issue influenced by historical actions, socioeconomic circumstances and community experiences rather than a physical or a geological event. An interpretivist epistemological approach highlighted that it is necessary to understand subjective points of view rather than just assessing objective factors about lived experiences, traditional knowledge systems, and community perceptions of landslides in Kothmale. The inductive approach is used to encourage the emergence of perceptions from participants' experiences. Furthermore, a qualitative research strategy was used because it discovered a comprehensive and context – based interpretation of landslide vulnerability and resilience in Kothmale.

Study Area

The research was conducted in the Kothmale DSD, Nuwara Eliya District, Central Province, Sri Lanka. Kothmale DSD has a total population of 103,697 with 96 Grama Niladhari Divisions. Furthermore,

Kothmale DSD is located in the Central Highland of Sri Lanka, which is highly vulnerable to landslide disasters (Senavirathna, 2001).

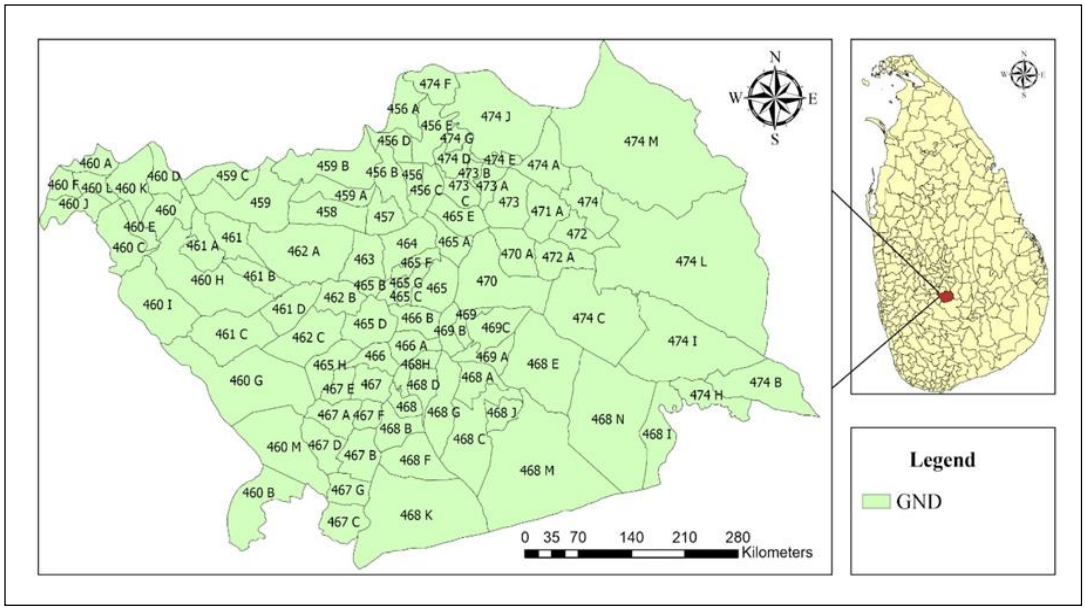

Figure 1: Study Area

Source: Prepared by Author

Research Design

Kothmale has a geographical vulnerability to landslides and a unique history. These distinctive characteristics make Kothmale itself an object of interest. That required an in-depth explanation of the region's special features and a case study research design most suitable to fulfil this requirement. Instead of generalizing the results, the case study highlights the contextual richness.

Sampling Method

The purposive sampling method was used to select participants. This helps to gather rich and context-specific data in the study area. In this study, there were 25 participants selected under the purposive sampling method.

Because traditional knowledge is frequently passed orally through social structures, snowball sampling was useful for identifying knowledge holders. In this study, the researcher was allowed to collect rich data with a level of data saturation with the 05 participants

Table 1: Selection of Participants based on the Sampling Methods

Sampling Method	Type of Participants	Number of Participants
Purposive Sampling	Divisional Secretariat officers	02
	Grama Niladhari Officers	05
	Households in landslide – prone areas	15
	Worker of the mini hydro power house	01
	Geography teacher	01
	Retired principal	01
Snowball Sampling	Traditional knowledge holders such as elders, long-term residents, and farmers	05
	Total	30

Source: Prepared by Author

Data Collection Method

In this study, 4 focus group discussions were held with 15 participants. The main purpose was to gather enriched data. Furthermore, the group dynamic supported respondents in one another's opinions and produced ideas that they may not have considered in a personal interview.

Semi-structured interviews enabled the interviewer to ask follow-up questions based on the responses, resulting in new insights or unexpected themes associated with the study. In this study, 07 semi-structured interviews were conducted.

Unstructured interviews were used for conversations with community elders and local leaders who have traditional knowledge and personal experiences with landslides. The main purpose of applying this to research was to provide participants with the opportunity to raise topics or perspectives that shed new light on the research topic and to enrich the study from different perspectives.

Table 2: Participants' Distribution based on the Data Collection Methods

Data Collection Method	Type of Participants	Number of Participants
Focus Group Discussions	Households in landslide – prone areas	15
Semi-structured interview	Divisional Secretariat officers	05
	Grama Niladhari Officers	02
	Worker of the mini hydro power house	01
Unstructured interview	Traditional knowledge holders such as elders, long-term residents, and farmers	05
	Geography teacher	01
	Retired principal	01
	Total	30

Source: Prepared by Author

Data Analysis Method

Data gathered from FGDs, semi – structured interviews and unstructured interviews were analysed using Braun and Clarke's (2006) thematic analysis framework. The research used an inductive coding strategy, which enable to identify themes from collected data. Similar codes were grouped into broader themes like Socio-economic drivers of occurrences of landslide, Impact of Landslides on Socio-economic Dynamics, Traditional Knowledge (TK) and Indigenous Coping Strategies in Landslide Risk Management in Kothmale and Integrating Traditional Knowledge with Modern Disaster Risk Management (DRM). The data analysis was done manually without the assistance of qualitative data analysis software. The interpretation of the results was shaped by the theoretical framework of the study. Those concepts were the socio–ecological systems (SESs) theory, political ecology theory, social responsibility, vulnerability and resilience.

Ethical Consideration

This research followed the ethical standards introduced by the Economic and Social Research Council (ESRC) of the United Kingdom. Participation was completely voluntary and anonymous identities were used to protect participants' identity. Participants had the freedom to cancel their participation at any stage, and sensitive information was handled confidentially.

Results and Discussion

Socio-economic drivers of occurrences of landslide disasters in Kothmale

Land-use Changes and Development Interventions

Land-use change and the expansion of populations have been identified as important socioeconomic factors of increased landslide risk in mountainous regions (Senanayake et al., 2020). Therefore, in order to explain landslide susceptibility in Kothmale, it is crucial to comprehend the link between the growth of populations and land-use change. Historical analysis based on the Mahawamsha stated that early settlements in the Kothmale were made up of small villages like “Pelwissa”, which was a settlement of about twenty households (Senevirathna, 2001). Due to the availability of water supplies and suitable soils for agriculture, these early villages were primarily found near river valleys. Hence, human activity was mostly restricted to the Kothmale valley's lower altitudes, leaving the upper mountainous regions as basically untouched watershed zones that sustained the Mahaweli River basin's biological balance (Senevirathna, 2001). Because of the lower population and land-use activities during this time, the demands on the natural landscape were comparatively small. While the population increased, new communities progressively spread out along the Kothmale valley's two sides and eventually reached the nearby higher mountains.

> Interview 01: “Before the construction of the Kotmale reservoir, people settled on both sides of the Kotmale Oya. The submerged Kadadora Temple is a good example of the temples, shrines and houses that emerge when the water in the reservoir recedes. But after the construction of the reservoir, people started coming and settling in the mountains like Thispane and Belton.”

According to the book “Sunset in a Valley - Kothmale” 2001, 35 settlements were created by settling 3, 431 families on 4,106 plots of land in areas such as Doragala, Harangala, Weliganga, Nugawela, Dangalla, Balapokuna, Riverside, Moragolla, Halgolla, Gorakaoya, Aluthwatta, Thispane, Monaragala, Belton, Navathispane, Kuduoya and Medathenna (Senevirathna, 2001). This trend of vertical expansion, notably with the establishment of the Kothmale Reservoir, resulted in a spatial change in settlement patterns from the lower valley levels to higher altitudes along hilly terrain. Nowadays, a large number of the population lives at elevations between 2000m - 4000m, which were originally very

isolated and marked by steep slopes and sensitive geological characteristics. These regions are particularly vulnerable to slope instability since many of them have slope angles greater than 45 degrees. Additionally, field observations show that cutting steep slopes vertically without sufficient technical assistance or slope stabilization measures is a common part of preparing land for home building. These actions make the landscape less structurally stable and raise the risk of landslides, particularly during periods of heavy precipitation.

> Interview 02: "Several houses in the Aluthwatta area below the Kalapitiya tank were evacuated due to a landslide."

According to research done by Senanayake et al. (2020) and Perera et al. (2018), in Sri Lanka, changes in hydrological patterns and land use have a major impact on the likelihood of landslides by affecting soil moisture levels and slope stability. Communities in the Kothmale area often build small tanks or ponds that store water from springs and streams to meet their domestic and agricultural water needs. The Kalapitiya tank mentioned above interview was built for agricultural needs in this area (Senevirathne, 2001). Although these water sources provide essential supplies for rural life, they can also increase groundwater saturation on nearby slopes. Especially in areas where the geological structure is already unstable, increased water absorption erodes soil stability and contributes to the initiation of landslides.

Furthermore, a study carried out by Haigh and Rawat (2011) mentioned that blasting and excavation in mountainous terrain weaken the geological structures, decrease soil stability, increase fractures and trigger the landslide vulnerability. In the case of the Kothmale region, major engineering buildings such as underground tunnels, water diversion systems, and power plants situated in hilly areas are part of the project.

> Interview 03: "When the Kothmale reservoir was built, I was about 15 years old. There were rock drills and blasting to supply stone need for construction reservoir. We could hear the noise even in our homes. Our houses were shaken too."

This interview demonstrated how technical changes related to hydropower production in the Kothmale region might unintentionally change underground structures and raise underground pressures inside layers of rock, collapsing slopes.

Another example of how massive infrastructure projects can affect slope stability is the Niyamgandora tunnel, which is a component of the Upper Kothmale hydropower system.

> Focus Group Discussion 02 – Participant 01: "The tunnel that carries water from the Upper Kothmale Reservoir to the Niyangandara Power House is located below the Choisiya, Kumbaloluwa and Niyangandara villages. With Ditwa, the walls of many villages above the tunnel collapsed, and many of the floors of houses cracked. Some houses were completely destroyed."

Groundwater flow and increased soil saturation are widely accepted as major triggers for landslides in mountainous areas (Haig and Rawat, 2011; Ahmed, 2021). This interview has demonstrated how changes of geological structure brought about by reservoir building and water diversion have a negative impact on slope stability and raise the likelihood of mass movements in mountainous areas such as Kothmale.

Another significant element causing environmental instability and raising the risk of landslides in hilly locations like Kothmale is road development and extension (Haigh & Rawat, 2011). As a result, natural landscapes were significantly impacted by digging and slope cutting.

> Interview 04: "All the roads in Kothmale were widened, tarred and repaired. That was good. But because of that, all the roads were blocked during the Ditwa Cyclone. Although the mountains were cut down when the roads were widened, no embankments were built to withstand the rain. All the trees and rocks on both sides of the road fell onto the road."

This statement demonstrated how improper slope protection techniques during road enlargement might make a route and area more vulnerable to disasters. Heavy rainfall could quickly cause the soil structure to become unstable when mountain slopes are cut without adequate retaining walls or drainage systems. The removal of trees along road sides minimizes root reinforcement, which helps keep the soil stable (Ahmed, 2021; Haigh and Rawat, 2011). As a result, during extreme weather conditions like the Ditwa cyclone, landslides, fallen trees, and slope collapses can disrupt transportation and danger surrounding populations. During the Ditwa cyclone, this transportation network issue triggered the negative consequences of the landslide disaster in Kothmale. Large-scale landslides occurred. However, the people of the area were unable to leave the Kothmale area, and even relief teams were unable to enter the Kothmale area to help the affected people due to the blockage of these roads.

Agricultural Dependence and Livelihood Practices

In the Kothmale region, historically, agriculture was the main source of income, influencing local populations' connections with the environment as well as their economic structure (Senevirathna, 2001). However, because of environmental restrictions, colonial interventions, and changing socioeconomic circumstances, agricultural practices in this area have experienced substantial changes.

In the past, Kothmale's agricultural landscape was made up of paddy farming and household gardens, both of which were environmentally acceptable and practical practices. Johansson (1989) states that when paddy fields were concentrated in valley bottoms with sophisticated irrigation systems, hills around the valley were often used for multi-layered domestic gardens. In this area, home gardens were designed as complicated polyculture systems with several vegetation strata. Such vegetation cover is especially crucial in landslide-prone regions like Kothmale since soil erosion and slope instability are major causes of landslide disasters. Similarly, paddy cultivation has a substantial impact on slope and water management. For long periods of time, paddy fields stayed wet, acting as organic sediment traps and lowering surface runoff and soil erosion. Additionally, traditional irrigation methods, such as small-sized tanks and canals, assisted in controlling the flow of water across the terrain (Putra et al., 2021). The Kothmale region has 258 irrigation canals, which suggests a well-run water system (Senevirathna, 2001). As a result, these traditional farming practices helped to preserve environmental stability and decrease landslide susceptibility by maintaining vegetation cover, controlling water transportation, and protecting soil structure.

> Interview 05: "During the British era, entire upper part of the Thawalanthenna, Belton and from Mahaweligama to Bogahawaththa was cultivated with tea plantation."

However, the agrarian environment of Kothmale rapidly transformed during the colonial period as plantation agriculture expanded. Significant amounts of natural forests and traditional agricultural lands were transformed into commercial plantations as a result of colonial economic decisions that promoted the cultivation of commercial crops like coffee and tea in the central highlands (Senevirathna, 2001). The mountainous environment's natural equilibrium was drastically changed by this legacy. As plantation-based farming became more prevalent, monoculture crop production, especially tea cultivation, replaced diverse agricultural systems. According to research done in the Kothmale DSD, tea planting has taken over as the primary land-use pattern in many of the Kothmale's highland areas (Fernando et al., 2023). On the other hand, large patches of the ground between rows of tea trees are frequently visible on these monoculture plantations. The exposed soil surface is extremely vulnerable to erosion when these crops are neglected or inadequately managed. This erosion can make the soil less structurally stable and raise the risk of landslides in steep hilly regions (Subasinghe and Kawasaki, 2021).

> Focus Group Discussion 01- Participant 02: "My main income source is daily wage labour at Belton tea estate. We can't earn enough money from paddy cultivation, because with the weather conditions it depended. But with working in a tea estate, I can earn a regular salary for my family expenses."

This point of view focuses attention on a crucial problem: plantation labour offers a steady daily income, whereas traditional agriculture depends on the environment. Because of this, many farmers have increasingly given up on home gardening and paddy farming. Hence, traditional ecological farming methods that historically contributed to slope stability have decreased as a result of this change in livelihood patterns, increasing dependency on plantation economics.

Additionally, the increasing popularity of plantation agriculture is directly linked to land clearance, infrastructure construction, and slope cutting, all of which enhance the danger of landslides. According to Senevirathna (2001), plantation growth has two main negative effects on the environment. The first effect was land degradation and forest clearance, which means the natural vegetation canopy was removed by extensive forest clearing, which increased soil erosion and sedimentation. The second effect was the disturbance of natural water streams, which forests that originally sheltered water sources and controlled stream flow were transformed into plantations, reducing water availability and increasing surface runoff and increasing the landslide vulnerability.

Poverty, Inequality and Vulnerability

Poverty is commonly acknowledged as a major factor contributing to disaster vulnerability in developing nations. From the viewpoint of a disaster risk, poverty is characterized by low income as well as restricted access to resources, possibilities, and support services that assist individuals in safeguarding themselves against environmental risks (Gallardo, 2017).

One focus group participant said that individuals are unable to construct appropriate slope protection measures around their homes due to limited funds. This scenario is also reflected in the lives of local individuals who live in economically challenged circumstances.

> Focus Group Discussion 02 - Participant 03: “This land is inherited from our generation, where my house is built. Our father divided the land between my brother and me. I built this house new. There is a slope below here but I don't have enough money to buy another safe land. So, I built a temporary stone terrace using the stones I found when cutting the foundation. Otherwise, the soil would wash away. If I were to build a proper stone terrace, it would cost about Rs. 100,000.”

Communities' ability to invest in safe home development or slope protection is also reduced by a lack of funding. Many homes lack protective elements like retaining walls, drainage systems, or reinforced foundations since they are constructed with simple materials.

According to one interviewee, many individuals try to escape poverty by utilizing the natural resources that are readily available to around them.

> Focus Group Discussion 02 – Participant 01: "In last month there was my daughter's puberty party. I didn't have the money for it, so I sold two trees in the garden to get money."

This example shows how locals are encouraged to exploit trees and other natural resources as quick sources of revenue due to financial barriers. While selling timber from home gardens could offer temporary financial relief, the area's natural cover steadily decreases as a result of ongoing tree cutting. On steep slopes, vegetation is essential for stabilizing soil strata because plant roots bind the soil and lower surface runoff. The removal of trees increases the soil's exposure to rainfall, which raises the risk of instability of slopes and soil erosion (Herath, 2008). Therefore, timber exploitation and frequent tree cutting damage the natural resilience of hill slopes in mountainous areas like Kothmale.

Impact of Landslides on Socio-economic Dynamics in Kothmale

Housing Damage, Displacement and Population Changes in Kothmale

The devastation of homes and other residential properties is one of the most direct socioeconomic effects of landslides. According to studies, landslides often result in surface displacement, soil collapse, and debris flows that cause structural damage to a building (Bessason, 2019). Several landslides have historically happened in places like Kadadora, Aluthwatte, Kalapitiya, Hapugasthalawa, and Halgolla (Senvirathna, 2001). These disasters have drastically changed the local landscape of settlements.

Recent disaster incidents highlight the devastating impact of landslides on property and residential areas in the Kothmale region. Data gathered from the Kothmale East DSD indicates that local populations suffered severe socioeconomic harm as a result of the Ditwa cyclone disaster. This landslide has caused severe damage to villages such as Ramboda, Rambodagama, Niyangandora, Panangammana and Delumthalamada. A total of 9,108 persons in the area were impacted by the disaster, including 2,660 households. There were also reports of 20 missing people, 27 injured, and 32 confirmed deaths. There was also significant damage to homes, with 379 partly damaged and 134 entirely destroyed. Due to these effects, 676 families reached safety in the homes of relatives, and 1,700 households were sent to emergency shelters. These figures demonstrate the level of housing devastation and relocation brought on by landslide-related disasters in the Kothmale area. These widespread effects show how landslides and related extreme weather events may significantly alter patterns of settlement and raise socioeconomic risk in Kothmale.

> Focus Group Discussion 01 – Participant 03: "My main source of income is made Kitul honey and jaggery. Both my children are still studying. So how can I leave this village and my job just because there is a risk of landslides? I don't know of any other job."

Despite that, some locals are hesitant to relocate outside of Kothmale, where they are comfortable with the lifestyle, agricultural activities, economic pathways, and food supplies. In this regard, the study found that because residents are refusing to relocate outside of Kothmale, landslides are creating pressure in comparatively safe locations. The tension on scarce land resources has intensified as a result.

After landslides, relocation is a social and cultural problem in addition to a physical barrier. Social networks, familial ties, and community support systems are frequently disrupted when families relocate from their home regions. According to studies, relocating is likely to result in social isolation and make it harder to adjust to new surroundings (Sangasumana, 2018). Interviews in the Kothmale region also brought attention to this problem. One participant described the difficulties experienced by families who were requested to move because of the potential of landslides.

> Interview 06: "It's been 5 or 6 years since 16 families in this village were told to leave because of the risk of landslides. At that time, officers said they would give 16 lakhs. In my family, we have 7 people living with 3 children. Actually, that money isn't enough to buy land and build a house. On the other hand, all of us living in our village are relatives. When we buy new land and go to new places, we are left alone. In an emergency, there is no one to help us."

This statement demonstrates the practical difficulties that relocation programs frequently encounter, including insufficient pay, a shortage of suitable land, and the disruption of social relationships. Because of this, some families are unwilling to move, even if their homes are in a dangerous area.

Economic Impacts of Landslides in Kothmale

The Kothmale region's economic and service sectors are significantly impacted by landslides and other extreme weather occurrences. Over 1000 small enterprises are active in the Kothmale region, according to data obtained from the Kothmale Divisional Secretariat. Small-scale companies including apparel manufacturing, sweets businesses, kithul-related businesses, retail stores, and service-oriented firms are among these businesses. However, these commercial operations have suffered significant harm from natural disasters like the Ditwa cyclone and related landslides. According to statistics obtained by the Kothmale - East DSD, seven goods-based enterprises were completely destroyed, eight businesses were partially damaged, and eighteen businesses suffered minor damage. Furthermore, four enterprises in the service sector suffered total loss, twenty-two suffered partial damage, and forty-three suffered minor damage. These damages disrupted the operations of many local businesses, reducing income opportunities for many.

One interviewee explained how local agricultural operations have been impacted by landslides that occurred in the Ditwa cyclone.

> Interview 07: "Rambodagama is a village with a long history of paddy fields. After the Rambodagama landslide, the paddy fields were completely covered with mud and rocks. Today paddy farmers had been unable to use those lands for cultivation again."

This kind of land degradation lowers food production and encourages impacted people to look for other kinds of livelihood. According to disaster studies carried out in Sri Lanka, landslides frequently result in long-term agricultural decline in impacted regions since rebuilding damaged land needs large technical and financial funds (Perera et al., 2018).

Landslides and relocation policies can also make life tough for people who rely on cattle husbandry. In Kothmale, a large number of rural families rely on dairy farming and another small-scale animal husbandry. However, migration from landslide-prone regions could put at risk these livelihood activities since new settlement sites may lack enough land or favourable conditions for living. The difficulties of moving animal-based livelihoods were outlined by one interviewee.

> Focus Group Discussion 03 – Participant 01: "We were told to leave from our house because there was a risk of landslides. But can we take all our cows, goats, and chickens and settle somewhere else? We don't have a big problem raising animals in this village. There are no problems from the people around us. But if we buy a piece of land, there should be enough space to raise animals. There should also be no issues from the people around us. We can't fight with people because of the smell and noise of these animals."

The devastation of infrastructure is another significant economic effect of landslides. Transportation of commodities, market access, and the provision of public services are all seriously hindered by infrastructure damage (Bessason, 2019). As a result, transportation delays may cause farmers and plantation workers to have lost revenues. A participant in the interview explained this circumstance during recent natural disasters.

> Interview 08: "I work at a tea factory nearby. When the landslides hit on November 27, the roads were blocked for several days. Although I was able to walk to the factory, the transport of tea leaves to work at the factory stopped, and workers living far away were unable to work at the factory because their roads were blocked. There was also no electricity due to the landslides. The factory started to work with a smaller amount of tea and workers after 2 weeks."

> Focus Group Discussion 03 – Participant 01: "Our main source of income is dairy farming. We raise cows and goats to produce milk. In addition, we raise chickens to sell eggs. When Ditwa hit, we couldn't sell any of these things. The roads were blocked. Finally, we gave milk and eggs to everyone around our house for free."

These statements demonstrated how rural market systems are disrupted by landslides and associated crises. Farmers are unable to deliver perishable goods like milk and eggs to markets when roads are closed. This results in the waste of animals and farm supplies, which can cause households that rely on daily sales for revenue to suffer direct financial losses. In addition, industries such as tea cultivation have also been badly affected by the landslide disaster in the Kothmale area. These examples also illustrate how the Kothmale area has been economically challenged by the landslide disaster.

The tourism industry in Kothmale was negatively impacted by the landslide disaster. The Karnagala View Point in Kothmale is a recently built tourist attraction point. Along with this, hotels and transportation facilities have developed in the area. However, due to the Ditwa cyclone, the entire tourist spot has been destroyed. Even the hotels that were built have been destroyed. This landslide, which started above the Karnagala View Point, had reached the Niyangandora Rajamaha Viharaya. The Niyangandora Rajamaha Viharaya is an ancient temple with historical value. This sacred place, which had been a tourist attraction, has also been damaged by the landslide.

Poverty and Recovery Challenges

Many households in the Kothmale region generate incomes from small-scale rural industry, plantation labour, and agriculture (Resource Profile -Kothmale East DSD, 2025). These sources of revenue may be temporarily or permanently lost when landslides destroy farms, block public transportation, or cause problems with regular business operations. Affected households thus struggle strongly to pay for everyday necessities (Ahmed, 2021; Bista, 2020). Moreover, because households must spend on mitigation efforts in order to minimize the probability of future disasters, landslides can result in additional financial burdens. To stop soil erosion and slope instability around their dwellings, people in hilly places like Kothmale frequently have to build stone terraces, retaining walls, and drainage systems. However, many low-income households are unable to afford the substantial financial commitment required for these mitigating measures (Ahmed, 2021; Bista, 2020).

Based on the idea of focus group discussion 02 – participant 03, which illustrated how vulnerable households may experience financial hardship as a result of disaster risk mitigation strategies. Houses are nevertheless vulnerable to soil erosion and landslide hazards due to a shortage of appropriate engineering structures and money.

Many homes in landslide-prone locations suffer structural damage such as cracked walls, broken foundations, and ground subsidence, in addition to mitigating expenses. Large financial investments are needed to repair these losses or build new homes, which puts more stress on the impacted families' financial situation.

Interview 09: “Many houses in our village, including mine, had cracks in the walls and floors after the landslides. Some houses were unsafe to live in. Building a new house now costs a lot of money, and many families can’t afford it.” (Figure 2)

Figure 2: Cracks in the wall and floor of the house
Source: Taken by the author during field visits

Traditional Knowledge (TK) and Indigenous Coping Strategies in Landslide Risk Management in Kothmale

Traditional Environmental Indicators Used for Landslide Prediction

One noticeable sign in the Kothmale region is the formation of strange soil cracks or fractures on slopes (Figure 3) or near residential structures. Those cracks are frequently seen as indicators of failing soil structures and ground movement. The expansion of these breaks during periods of high rainfall is seen by locals as a potential indicator of landslide activity. Changes in water flow patterns are another indication that locals have noticed. Sudden loss of water sources or changes in groundwater flow could indicate subsurface soil movement. Since it indicates that soil layers have been disturbed, the appearance of muddy water springs is also seen as a significant warning indicator for a landslide incident.

Figure 3: Fractures on Slopes

Source: Photograph provided by a participant during field visits

> Interview 10: "Under our house, we heard a strange noise. Then we informed the relevant officials. After that, the officials conducted a technical inspection and accepted that our village was at risk of landslides."

Along with these signs, locals often describe hearing strange sounds coming from the ground, such as booming or cracking sounds when it rains heavily. These noises are considered to be indicators of soil movement under the surface. These observations help local populations identify possible landslide hazards and take preventative measures, such as keeping an eye on dangerous locations or temporarily moving during periods of high rainfall.

Traditional Water Management in Kothmale

According to research on Sri Lanka's traditional agricultural landscapes, Indigenous methods for dealing with water were tightly linked to the natural environment and were crucial to preserving ecological stability (Johansson, 1989; Senevirathna, 2001).

This cultural connection to natural water sources is further supported by data from field interviews in Kothmale. One participant described how previous generations used wells and natural springs to meet their daily water needs.

> Focus Group Discussion 04 – Participant 02: "In our village, there were places famous for water springs earlier. People used to get water from wells created based on natural springs, like Dambagollawatta well and Mahapilla well. But now, each and every house has a piped system."

This statement suggested that rather than controlling the landscape's natural water flow, traditional cultures depended on naturally occurring water sources like springs and rivers. People preserved the area's natural drainage routes by utilizing these naturally occurring water sources. These methods mitigated the possibility of slope instability brought on by man-made changes to water flow and helped safeguard groundwater systems.

Traditional Land Use Practices in Kothmale

Terrace farming (Figure 4) is one of the most significant traditional methods utilized in hilly regions. To produce a suitable surface for agriculture, farmers construct terraces on steep hillsides. Terracing keeps soil from washing away during periods of intense rainfall and helps decrease surface runoff. Terraces increase slope resilience and minimize soil degradation by controlling water flow and holding soil in place (Chandrasekara et al., 2017). Residents of Kothmale still employ this technique on steeply sloping paddy cultivation terrain. In Kothmale, terraces are now often utilized for the production of tea and vegetables.

Figure 4: Terrace Farming in Kothmale
Source: Taken by the author during field visits

Another tradition-based technique in the Kothmale is to maintain home gardens with tree stratification, which involves cultivating diverse plant species in numerous vertical strata. Farmers cultivate a variety of plants at various levels, including fruit trees, coconut trees, coffee plants, spices, and vegetables. This

layered plant pattern enhances water penetration while sheltering the soil's surface from the direct effects of rainfall.

> Interview 11: “There is a slope below my house. My father built a stone terrace to prevent soil erosion on our land. Even today, none of those stones has moved. The stone terrace is still standing, unbroken.”

This interview showed that traditional stone terraces may successfully prevent soil erosion and stay stable for extended periods of time. By retaining soil layers and minimizing the effects of surface runoff during periods of high rainfall, these structures protect the sloped area. In order to stabilize slopes and mitigate the risk of landslides in the Kothmale region, local populations' continuous usage of stone terraces is a significant traditional soil protection approach. But the socioeconomic potential of households can also be influenced by the capability to build and maintain this kind of stone terrace. Families with less economic stability may face difficulties in implementing protective mechanisms like a stone terrace.

Traditional Agroforestry Practices in Kothmale

Field interviews conducted in the Kothmale region demonstrated how local populations have traditionally strengthened soil layers in home gardens by using particular tree species. According to one participant, the tree known locally as “Yakada Maran” (Syzygium zeylanicum), which has a strong and extensively widespread root structure, was planted by previous generations.

> Interview 12: “Our grandfathers planted a tree called ‘Yakada Maran’ in past. These trees have a strong root system and spread over a vast area. That tree contributed to the stratification of the garden and strengthens soil stability.”

In Sri Lanka's tropical forest ecosystems, Syzygium trees are often discovered in mid-slope and valley settings, where they support ecological stability and forest structure (Gamage et al., 2013). In natural forest settings, their root systems support the vegetation layers and contribute in binding soil particles. Because they improve soil stability and prevent erosion, these tree species are crucial to traditional agroforestry systems. Thus, in addition to promoting agricultural output, the custom of keeping layered household gardens with deeply rooted trees like Syzygium zeylanicum also helped to preserve soil and stabilize slopes in the Kothmale terrain.

In order to decrease the risk of soil erosion and landslides, local populations strategically plant bamboo close to slopes, stream banks, and garden boundaries.

> Interview 13: "In the past, people planted bamboo trees along the edges of land and slopes. They also planted bamboo bushes on both sides of the canals and small water streams. The roots spread widely under the soil. Therefore, the soil was not easily washed away during heavy rains."

According to research on bamboo ecosystems (Lobovikov et al., 2007; Nath et al., 2015), due to the bamboo's root structure creates a natural barrier that keeps soil layers from being washed away, and bamboo vegetation dramatically decreases soil erosion and land degradation in steep environments. As a result, bamboo planting has long been acknowledged as a successful biological technique for stabilizing slopes and conserving soil.

This research found that numerous traditional environmental techniques that were formerly widespread in the area are now not much used. For instance, ancient irrigation methods, natural water sources, and ecological land management techniques that preserved environmental equilibrium were all very important to previous generations. However, the dependence on such traditional strategies has increasingly decreased due to modernization and infrastructural development. Disaster risk management is significantly impacted by the loss of traditional wisdom transfer.

Integrating Traditional Knowledge with Modern Disaster Risk Management (DRM)

Traditional approaches to disaster management often focus heavily on technology and scientific solutions, neglecting the important knowledge that local populations have acquired through long-term interactions with their surroundings. Research suggests that successful disaster risk reduction, particularly in rural and environmentally vulnerable areas, requires integrating scientific information with TK systems (Mercer et al., 2010; Hiwasaki et al., 2014). In areas like Kothmale, where landslides are a common threat, the local population has a thorough knowledge of environmental indicators, traditional land use practices, and slope stabilization strategies. As a result, incorporating this information into official DRM initiatives can greatly improve community resilience and preparedness.

TK cannot be fully incorporated into formal disaster management systems due to a number of institutional barriers. One significant problem is the dominance of top-down approaches, where central authorities make disaster management choices with little input from the community. These approaches often ignore the importance of local experiences and local knowledge (Mercer et al., 2010). But when considering the Kothmale region, it became clear that even though this top-down approach was in place, lower-level officials were identifying and utilizing regional knowledge systems related to landslide disasters. Interviews conducted in the Kothmale area revealed that relevant officials have identified traditional knowledge and practices. These include, in particular, landslide warnings and mitigation

practices. The study found that these have been incorporated into official disaster management frameworks at the GN and district levels.

> Interview 14: "The Grama Niladhari came during the rainy season and told people to leave their homes as soon as possible if they emerged new water springs and strange noises from under the ground."

> Interview 15: "Our main source of income is tea plantations. When agricultural service officers come to inspect tea plantations, they tell us to plant 'shade trees' in the plantations."

This statement highlights the relationship between formal disaster management institutions and local communities.

A key strategy for enhancing regional preparedness and resilience in response to disasters is community-based disaster risk reduction (CBDRR). This method places a strong emphasis on local communities' involvement in hazard identification, preparedness planning, and mitigation. Shaw (2012) argues that because local communities have in-depth knowledge of environmental variables and past hazard patterns, community engagement is crucial for successful disaster management. The establishment of community awareness initiatives that inform locals about disaster risks and preparedness techniques is a crucial part of CBDRM. Communities may learn about traditional and scientific methods of disaster risk management through awareness campaigns. These initiatives could inspire locals in places like Kothmale to integrate traditional environmental knowledge with contemporary early warning systems and hazards monitoring methods.

Furthermore, recording traditional knowledge is a crucial step in maintaining traditional environmental practices. The decline of important information that has been established over many generations can be avoided by documenting local knowledge about water management systems, traditional slope management practices, and landslide indicators. Numerous traditional methods, like building stone terraces, cultivating bamboo, and using agroforestry systems, have traditionally helped to stabilize slopes and conserve soil, as evidenced by the interviews done in Kothmale. Policy frameworks can also help to integrate traditional knowledge by encouraging community involvement in disaster preparation, promoting sustainable land management techniques, and fostering local environmental preservation initiatives. Policies that support traditional water management techniques, vegetation-based slope stabilization, and community monitoring of environmental indicators might improve long-term catastrophe resilience in landslide-prone places like Kothmale.

Therefore, communities, local government agencies, and national disaster management organizations must work together to integrate TK with contemporary disaster risk management. Policymakers may

create more inclusive and successful disaster risk reduction plans that are better adapted to local environmental and socioeconomic conditions by acknowledging and promoting indigenous environmental knowledge.

From a social responsibility perspective, disaster risk management is a shared responsibility between governments, communities and individuals, rather than being a technical or institutional task. This perspective highlights that everyone involved has a responsibility to actively participate in risk reduction initiatives to protect people's lives, livelihoods and the environment (Chen et al., 2024). In the context of Kothmale, incorporating traditional knowledge into contemporary disaster risk management is a shared responsibility to identify and use locally accessible knowledge systems for the benefit of society. Communities have a role to play in maintaining, disseminating and using their traditional knowledge, and government institutions and disaster management authorities have an obligation to recognize indigenous traditions and incorporate them into official policy. Participatory planning procedures, awareness campaigns and community-based strategies all demonstrate shared responsibility, with residents and institutions working together to reduce disaster risk. Thus, integrating traditional knowledge in Kothmale with contemporary DRM can be considered a socially conscious strategy that supports inclusive, sustainable and community-centered disaster management.

Conclusion

This study explored a two-way relationship between socio-economic dynamics and landslide occurrence in Kotmale, highlighting that landslides are strongly influenced by historical development patterns and human activities rather than purely natural incidents. Poverty, infrastructure development, plantation agriculture, population growth, and land-use change greatly increase community vulnerability to landslides. Landslides also exacerbate socioeconomic problems by causing financial instability, livelihood disruption, and displacement. Especially, the study found that traditional knowledge is essential for improving community resilience through sustainable land management techniques and early warning indicators. However, there is a visible gap in the intergenerational transfer of such knowledge. The study also emphasizes how community-based resilience may be greatly strengthened by combining traditional knowledge with contemporary DRM techniques. In order to create more context-specific and long-lasting solutions, methods like CBDRM and participatory planning offer useful avenues for integrating local expertise with a scientific foundation. By focusing on the sociocultural and knowledge-based aspects of landslide risk in a unique and vulnerable environment like Kotmale, this study fills a significant gap in the literature of previous studies. The study uses a qualitative technique to gather community perspectives, which provides a deeper understanding of local realities and adaptation strategies, in contrast to many other studies that focus on

technical and physical factors. The study concludes that a broad approach that incorporates traditional knowledge systems, environmental management, and socioeconomic factors is necessary for Sustainable Landslide Disaster Risk Management in Kothmale. Building long-term community resilience requires boosting the acknowledgement, recording, and use of traditional knowledge in collaboration with contemporary scientific methods. Thus, this study makes a theoretical and practical contribution to the creation of more sustainable and inclusive disaster risk management plans in Sri Lanka.

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