# Local Knowledge Adaptations for Landslide Disasters Risk Reduction in Rural Mountain Communities

(中山間地域における地すべり災害リスク軽減を目的としたローカル・ナレッジ活用に関する研究)

By

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Supervised by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Engineering

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# Declaration

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at Nagaoka University of Technology or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of Nagaoka University of Technology concerning plagiarism and intellectual property.

# Abstract

Natural disasters are unforeseen events which occur at hydrologic, geologic, and atmospheric origins. Natural disasters and climate change become the most common issues and the consequences are extremely diverse. Major disasters such as flood, landslide, earthquake, tsunami, and drought etc. are perplexing for prior prediction and can result the environmental degradation by reducing the capacity of environment to attain social and ecological needs. In many parts of the world, landslides/earth slips had become a major type of disaster which is triggered due to natural and human induced reasons. The downward movement of slope-forming material such as soil, boulder, weather rock, intact rock and composition of them, along with groundwater and surface water, driven by gravity and triggered by rise of groundwater, and/or other factors such as erosion and rainfall form the landslide. Moreover, landslide disasters occur suddenly, causing multiple socio-economic burdens on developing countries. Preserving and enhancing adapting capacity of locals to landslide disasters is a sustainable solution. Few villages are still sustainably surviving and dealing with the damages caused by landslides by adopting to local knowledge and subsequently, passing the knowledge to the next generations. The Policy-makers still rely on mitigation strategies based on scientific approaches. However, many scholars had emphasized the importance of incorporating local knowledge and related practices for disaster risk management. In that context, initially this study investigates the local knowledge in adaptation to mitigate the landslides disaster situations by studying a village in Sri Lanka which is located at the central region of Sri Lanka which is vulnerable for landslide disasters. Other than that rural depopulation in mountain communities is now well acknowledged as one of the salient challenges faced by Japan which made

them more susceptible to landslide disasters with intense weather conditions. The degradation of the traditional culture due to the rapid depopulation in mountainous areas leads to the permanent disappearance of the best local knowledge for landslide disasters. Therefore secondly, this study attempts to investigate the community's landslide hazard knowledge in depopulating mountain communities in Japan. This study employed the field surveys, questionnaire surveys and semi structured interviews for data collection. Firstly, the analysis has been conducted for identifying the main components in local knowledge on landslide disasters. Based on the component's results, the questionnaire was developed to measure awareness on those components within the community. Finally, the cultural consensus modelling was utilized in discovering the cultural truths not in individual responses but the degree of sharing of these responses.

In addition, investigating social capital features and their influence on local knowledge transfer of landslide disasters is essential for preserving these valuable local knowledge systems. Thus, this study investigates the social capital features of two mountain villages in Sri Lanka since the communities residing in these villages have effectively adapted to landslide disasters. In-depth interviews and questionnaire surveys were conducted to collect data related to social networks and other social capital dimensions. Social network analysis was conducted to determine the structural dimensions of these communities, and text data coding was performed with the acquired interview data to analyze the cognitive and relational dimensions. Consequently, the elderly group was found to be the dominant group in transfer of local knowledge within the networks.

Finally ,the research outcomes suggest how the local knowledge-based practices and the consensus of local knowledge had improved the level of disaster adaptation among the community members. The findings of the research indicate how the local knowledge-based practices in settlement layout & planning, landscaping had enhanced disaster adaptation level of the community. Moreover, the findings presented the influence and importance of social capital in preserving the local knowledge system of landslide disaster.

# Dedication

This book is for you,***Father***. As a Father you embodied Me in so many ways: in personality, love of family, devotion to the gospel, and all your sacrifices in your life. You were well-loved everywhere you served. As you look down from heaven, I hope you30,fe,ff0”80”99re proud of your son.

**පිදුම**

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# Chapter 1

# Introduction

## 1.1 Background

Climate change and catastrophes become the most frequent problems and the consequences are extremely diverse.The likelihood of more droughts and worse storms will undoubtedly grow with rising global surface temperatures. Significant disasters including flooding, landslides, earthquakes, tsunamis, and droughts, among others, are difficult to forecast in advance and can induce environmental degradation by impairing the ecosystem to meet social and ecological needs. Landslides and earth slips have emerged into a significant category of disaster which can occur for both naturally occurring and human-caused reasons in various places of the world.Landslides is one of the severe types of disasters in hilly terrains and which cause to loss of lives and property damages especially in Asia region.Landslides mostly occur suddenly without any early indications, thus, making timely evacuation of people difficult [29]. Landslides have multiple vital global socio-economic implications. Progressively, multiple scientists agree that local knowledge can significantly reduce and manage environmental disaster risks, particularly in rural communities in developing countries [50, 75, 95].

Many communities all around the world have employed Local Knowledge as a survival strategy for natural disasters for many years. Following significant disasters, many accounts of how communities employed indigenous practices to safeguard lives and property have been shared.When it comes to identifying, measuring, and

monitoring disaster risks as well as improving early warning systems for disaster risk reduction initiatives at the local level, the input of indigenous local knowledge is a beneficial and successful disaster risk reduction intervention. Local expertise adds to the immense amount of information and skills which are emerging outside the official educational system [95]. Utilizing local knowledge is a technique that has long been ingrained in society as a whole. The framework for decision making and policy for communities in areas including food security, human and animal health, educational reform, and resource management is provided by it.
Disasters caused by landslides might have hydrologic, geologic, or atmospheric causes. Policymakers maintain their reliance on scientifically grounded mitigation options. However, a lot of academics have underlined how crucial it is to use local wisdom and related traditions while managing disaster risk. Indigenous wisdom is still frequently employed as an early warning mechanism for natural disasters [95]. However, mitigation solutions centered on scientific methods are still utilized by policymakers [50]. However, some remote mountain communities managed to adapt based on local knowledge and remain unaffected by landslides. The abundance of indigenous knowledge has not been fully acknowledged in the process of catastrophe risk reduction, despite the fact that there are more details available regarding indigenous knowledge mitigations. Additionally, there is a dearth of scientific documentation evidence.

This introduction chapter will provide the brief overview of disaster context and specially the severity of the landslide threats in Sri Lanka. Moreover, it will explain the detail of the research gap which indicates the requirement of this study. Additionally, this part of the thesis presents the specific objectives of the study and suggests the method to achieve these goals.

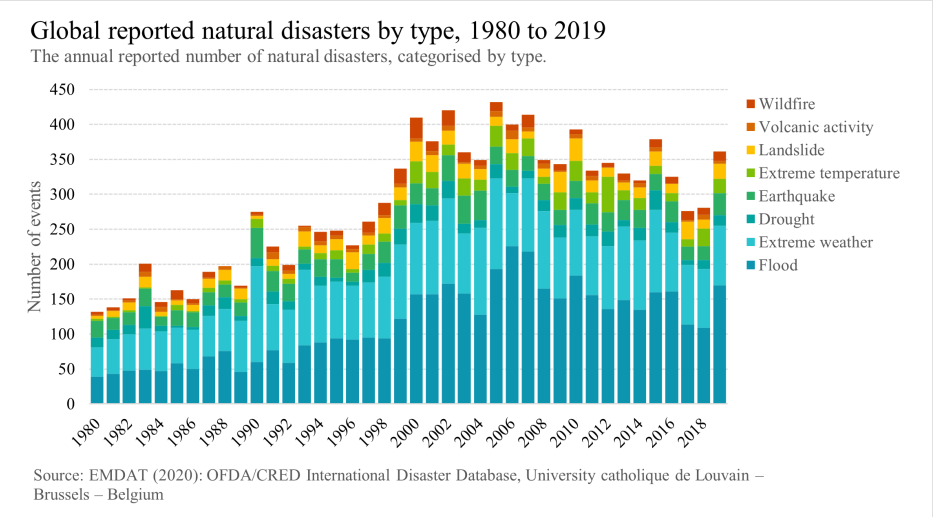



Figure 1.1: Global reported natural disasters by type

## 1.2 Conceptualisation of the key concepts

### 1.2.1 Local and Indigenous Knowledge

Local knowledge is sometimes referred to as indigenous knowledge, traditional knowledge, or local ecological knowledge [107]. It serves as the foundation of all environmental solutions for problems related to agriculture, health care sector, food preparation, natural resource management, education, etc.Indigenous Knowledge is defined by Mascarenhas [98] as the whole sum of knowledge and abilities possessed by the inhabitants of a particular geographical area, which enables them to maximize their natural environment. These talents and expertise are transmitted from generation to generation.

### 1.2.2 Disaster

Disasters are significant setbacks to a community's ability to operate that go beyond what it can handle on its own. Natural, man-made, and technical risks, as well as a number of other variables that affect a community's exposure and vulnerability, can all result in disasters.According to UNDRR [60] " A significant disruption of a society's ability to function on any scale caused on by risky occurrences interacting with exposure, vulnerability, and capacity conditions, which

may result in one or more of the following: Losses and effects relating to human, material, economic and environmental losses and impacts".

### 1.2.3 Disaster Management

Disaster management fundamentally refers to how we address the effects of a disaster on people, property, the economy, or the environment.The practice of efficiently planning for and responding to disasters is known as disaster management."Planning, organizing, coordinating, and implementing into action to effectively prevent and manage disasters constitute the ongoing and integrated cyclical process of disaster management [99]".

### 1.2.4 Landslide Hazard

Landslides are caused when slope-forming elements including soil, boulders, weathered rock, intact rock, and their composition slide downhill while being propelled by gravity, caused by rising groundwater, and/or other forces like erosion and rainfall. Landslides can be divided into different classes based on the material, speed and shape of movement, relationship with water, type of terrain they occur on, and magnitude or scale. The different types of landslides comprise falls, topples, slides, lateral spreads, flows, mass movements, creeps, collapse, cutting failures, rock falls, and complex of them [126].

### 1.2.5 Vulnerability

Vulnerability is a concept using in different research traditions [76], however, opinions on its significance differ. According to the research field, it has only been utilized for the social subsystem, the ecological, natural, or biophysical subsystem, or to the connected SES, which has also been described to as the target system, unit exposed, or scheme of reference. investigates how theories of vulnerability have developed through time and how they relate to the social and scientific sciences. He acknowledges the fact that exposure to disturbances or external stresses, sensitivity to disturbances, and the ability to adapt are the components that vulnerability

is most frequently conceived.

### 1.2.6 Social Capital

Social capital addresses the value of social connections in terms of competitive advantages derived from resources embedded in the social structure [55, 144]. Woolcock [155] defined social capital as, "encompassing the norms and networks facilitating collective action for mutual benefit." Three main types of social capital are identified by researchers [35].

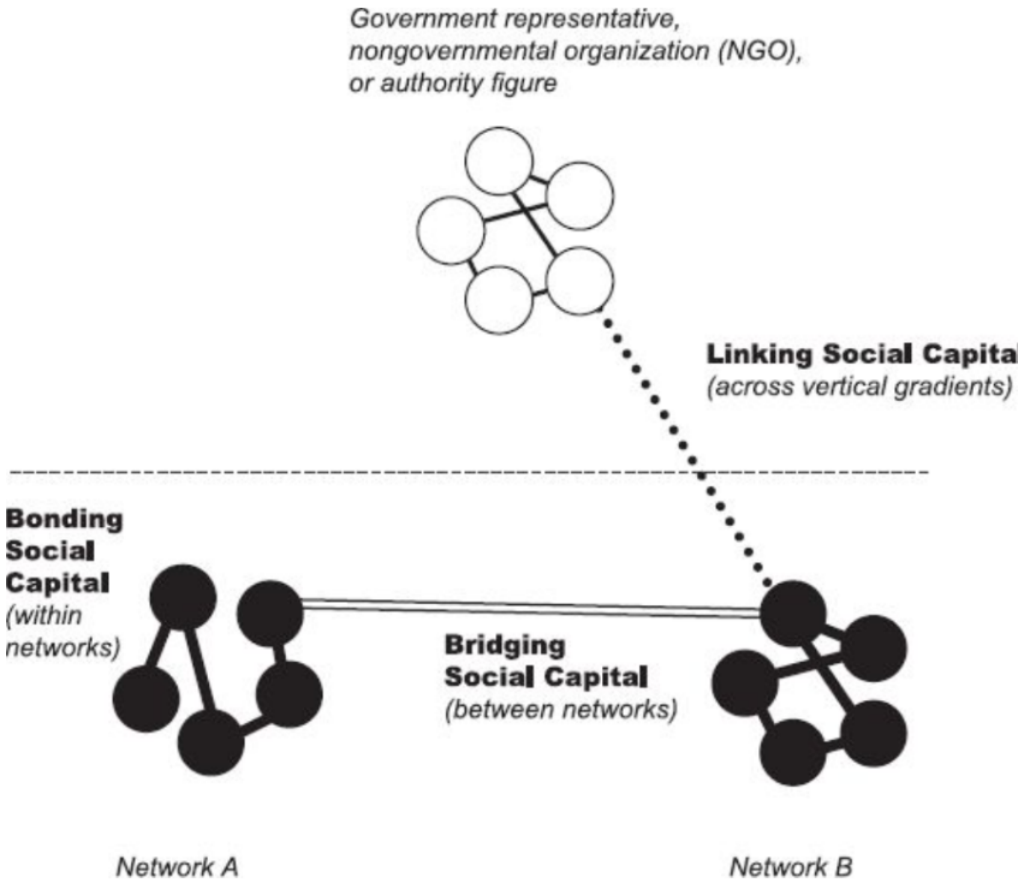



Figure 1.2: Types of Social Capital [52]

1. ***Bonding*:** Bonding refers to social capital created within a group with shared interests and goals. A neighborhood association is a good example of how bonding works.

2. ***Bridging*:** Bridging is the development of social capital across groups. When bridging is successful, people from the two groups identify common interests and objectives and collaborate to pursue them. An illustration of how bridging functions is a neighborhood group that collaborates with the local police force.

3. ***Linking*:** Linking, similar to bridging, linking creates ties across groups, but those that span different socioeconomic groups. Linking has been associated with increasing one's chances of upward social mobility.

### 1.2.7 Resilience

Resilient communities are far less susceptible to hazards and disasters than less resilient areas. Holling (1973) first applied the term resilience to describe a "measure of the persistence of systems and their ability for absorbing changes and disturbance and still preserve the same relationships between populations or state variables [34]". Like vulnerability, multiple definitions of resilience exist within the literature, with no approximately accepted single definition [69]. The global environmental change community has been very dynamic in further hypothesising resilience in human-environment relations [32]. In this research domain, resilience is defined as a system's capacity for absorbing disturbance and re-organizing into a fully functioning system. It contains not only a system's capacity to return to the state (or multiple states) that occurred before the disturbance, but also to advance the state through learning and adaptation [140]. Resilience is the ability of a social system for responding and recovering from disasters and includes those inherent situations that agree the system to absorb impacts and cope with an event, as well as post-event, adaptive procedures that enable the ability of the social system to re-organize, change, and learn in response to a threat. Vulnerability and resilience are dynamic procedures, but for measurement purposes are often regarded as static phenomena.

### 1.2.8 Adaptation

The terms 'coping' and 'adaptation' are used to describe the strategies deployed by community members in response to disasters. Generally, these terms have been used interchangeably [81]. "Coping" refers to the short-term and immediate measures implemented by individuals and communities, while "adaptation" involves livelihood progression beyond reactive responses. This study focuses on the long-term strategies and actions that have emerged and evolved in relation to landslide disasters. It argued that a community could adapt to landslide disasters if the community exhibited indigenous strategies and measures for landslide disaster risk reduction and if this knowledge was passed to their subsequent generations who resided in the same geographical areas, which were prone to landslide disasters [42].

## 1.3 Research Questions

The following research questions can be formulated in context of the problem statement:

- What are the existing local adaptation practices in landslide disaster prone central region in Sri Lanka?
- What are the existing local adaptation practices on landslide hazard in depopulated mountain communities in Japan?
- How the transfer and evolution of local knowledge occurred?
- What recommendations can be made to improve the role of Local Knowledge in landslide Disaster Risk Reduction in Sri Lanka?

## 1.4 Aim & Objectives

Mouton and Marais [108] state that the study aims or objectives give a broad idea of what researchers hope to accomplish in their research.The research objectives of the study are stated below.

### 1.4.1 Aim of the Study

The aim of this study is to explain and evaluate the effectiveness of adaptation in local responses for landslides disaster situations (pre-disaster, during disaster and after disaster) in Japan and Sri Lanka.

### 1.4.2 Specific objectives

The study consists of three main specific objectives:

- To identify, investigate and evaluate the local adaptation practices in landslide disaster prone central region in Sri Lanka.
- To investigate and evaluate the consensus of Local Knowledge on landslide hazard in depopulated mountain communities in Japan.
- To critically investigate the role of social capital in Local Knowledge evolution and transfer in a network of rural communities coping with landslide disasters.

## 1.5 Research Framework

### 1.5.1 Research methods

This research attempts to find the existence of local knowledge in adaptation to disaster situations referring to case studies at landslide disaster prone areas in Sri Lanka and Japan.At first,two case studies have selected from central hilly region in Matale District and Nuwara eliya District in Sri lanka. Secondly, case studies have selected from Matsunoyama village in Tokamachi Japan.The study conducted through extensive field studies. Research Techniques used for data collection include a questioner survey, in-depth interviews, focus groups discussions and Key informant interviews. The research's conclusions show how the community's level of catastrophe adaption was raised by indigenous knowledge-based methods in settlement layout planning and landscaping. Additionally, the results demonstrate the importance of social capital in the development and exchange of

local knowledge in a network of rural communities dealing with landslide disasters. Additionally, local knowledge-based value systems function as a powerful tool for spotting landslide hazard warning indications early on. The paper also addresses the potential for expanding such local disaster risk management approaches to more widespread use.

### 1.5.2 Literature Review

This chapter's aim is to present the theoretical foundation for this specific topic.It explains the important concepts, techniques as well as the review of the discovery from other researchers who have already published in the area of interest.

### 1.5.3 The Case Study

#### 1.5.3.1 Case Study in Sri Lanka

The present study focuses on two communities located in the Matale and Nuwara Eliya districts in the central mountainous region of Sri Lanka. The districts are majorly surrounded by central mountain ranges, which are young, have unstable geology, steep slopes, and climate that is difficult to predict. Due to the meteorological, geographical, and geological conditions, and socio-economic characteristics, some regions are highly susceptible to landslides. Therefore, this study selected two communities residing in the Etanwala and Mandaramnuwara villages, which have a long history of landslides, and are located in the Grama Niladari division. This study considers various aspects during the selection of case studies. It primarily assumes that the communities have already adapted to landslide disasters. Multiple reasons exist for considering this assumption. First, both communities have a history of landslides, but several generations still reside in the areas and have not changed their geographical locations. Second, spatial and non-spatial local adaptation measures for landslides were identified in both the communities. Therefore, this study assumes that Etanwala and Mandaramnuwara villages are sustainably adapted to landslide disasters.

#### 1.5.3.2 Case Study in Japan

The study was conducted in and with the community of the one mountain village named Matsunoyama, located in Tokamachi City. Matsunoyama, primarily surrounded by young mountain ranges, possesses steep slopes with unstable geology and a harsh climate to predict. Some areas are incredibly prone to landslides as a result of the meteorological, geographical, and geological conditions and socio-economic characteristics. Therefore, this study selected three communities residing in the Matsunoyama villages with a long history of landslides, located in the shūraku division. Mizunashi Settlement, Shimo Kawate Settlement (Combination of Matsuguchi and Mioke areas), and Fujikura Settlement were selected for this study based on the advice from the Officials in the Tokamachi city office.

### 1.5.4 Sampling

### 1.5.5 Data Collection and Analytical Methods

Interviews of the key informants, group discussions, and household surveys were conducted in the village communities selected in both Sri Lanka and Japan to collect data on Local Knowledge of landslide adaptations, social ties, and the evolution and transfer of a constituent of traditional knowledge. The degree of awareness of local knowledge and the level of consensus was examined using the descriptive analysis technique and the cultural consensus analysis. In addition, social network analysis and the grounded theory method were used to examine the evolution and transmission of local knowledge in a network of rural communities.

#### 1.5.5.1 Method of Data Collection

The initial community meeting was done with the responsible government officers appointed to each village in both countries, as in any qualitative study, it is a requirement that the researcher approaches the region and its people.

#### 1.5.5.2 Grounded Theory Approach

A grounded theory approach was used to find out the theoretical connections based on the study [61]. Furthermore, a continuous process was used to code the general themes. Grounded Theory Methodology (GTM) is a systematic, inductive and comparative approach for conducting research, where the purpose is to construct theory. The researcher maintains a constant reference to the data while being involved with the emerging analyses. Thus, the collection of data and its analysis proceed simultaneously, where each informs and optimizes the other. With the collected data, data analysis took place – with constant coding and comparison, which means taking the raw data to a conceptual level through a coding process [53,61,153].In this study, a continuous process was used to code the general themes.

#### 1.5.5.3 Centrality Parameters

Various methods exist to define and measure centrality in social networks. However, in this study, we focus on two important and distinct types of centrality: degree and betweenness [160]. For this study, village inhabitants are considered nodes in a network of social relations relevant to knowledge transfer. A node30,fe,ff0"80"99s degree centrality is simply a count of how many social connections it has [31]. Betweenness centrality is a person30,fe,ff0"80"99s role in allowing information to pass from one part of the network to another [84]. Higher values indicate that the node is more central for degree centrality, showing the number of connections a person has [31]. Therefore, in this study, degree centrality values are used to identify the individuals who have more connections or are dominant in the knowledge sharing network. They may be connected to many people at the heart of the network, but they might also be some other nodes that do not have a very high degree but can play a prominent role in allowing information to pass from one part of the network to the other [84]. Therefore, this study has used betweenness centrality values to capture the nodes, which are very important to the flow of information through a knowledge-sharing network. The betweenness centrality is simply a measurement of how it allows information to pass from one part of the network to the other. Thus, Degree centrality and Be-

tweenness centrality are used to identify dominant nodes and derive the network structure of the knowledge sharing network in a rural community.

***Degree centrality*:** Degree centrality defines the number of edges/ties connected to a node [157]. The measure expresses the extent to which a node contacts and directly affects the network. The initial formula of degree centrality (Cd) of node Ni is given in Equation (1). However, the size of the network may vary. Thus, to reduce the possible size effect on Cd measurement, Wasserman et al. standardized Equation (1) and proposed a new measurement (C'b) method, which is given in Equation (2) to estimate the number of links directly connected to node N [160].

$$Cd(Ni) = \sum_{j=1}^{n} Xij_{(i \neq \mathrm{J})} \tag{1.1}$$

$$C'd(Ni) = \frac{\sum_{j=1}^{n} Xij_{(i \neq \mathrm{J})}}{(n-1)(n-2)} \tag{1.2}$$

Cd (Ni): Degree centrality of node Ni.

C'd (Ni): Standardized degree centrality of node Ni.

Xij: Number of edges per individual.

n: Number of nodes in the focal network.

The C'd (Ni) value varies with the number of links, and ranges between 0 and 1 [160]. A value close to 0 indicates that the nodes do not have knowledge-sharing links, whereas a value close to 1 indicates that the nodes have multiple links. Subsequently, a node with a high C'd (Ni) value represents the dominant character of the network.

***Betweenness centrality*:** Betweenness centrality (Cb) is a measure of a person's role in passing information from one section of the network to another. Betweenness measures the importance of the node in information flow through a network. The basic formula of Cb is given in Equation (3). Wasserman et al. standardized Cb (C'b) by dividing it by (n - 1) (n - 2)/2; the subsequent standardized formula is given in Equation (4). In the two equations, Cb is the number of nodes (N)

between any other two nodes in the network [160].

$$Cb(Ni) = \sum_{j<k} \frac{G_{j,k}(Ni)}{G_{j,k}} \tag{1.3}$$

$$C'b(Ni) = \frac{2\sum_{j<k} \frac{G_{j,k}(Ni)}{G_{j,k}}}{(n-1)(n-2)} \tag{1.4}$$

Cb (Ni): Betweenness centrality of node Ni.

C'b (Ni): Standardized betweenness centrality of node Ni.

Gjk: Number of shortest paths between Nj and Nk.

Gjk (Ni): Number of shortest paths between Nj and Nk that pass through Ni.

The C'b (Ni) value can vary from 0 to 1. A value close to 0 indicates that the node does not assist the flow of knowledge through the network, whereas a value close to 1 indicates that the node is crucial in knowledge flow in the network. A node with a high C'b (Ni) value represents the dominant character within the network.

## 1.6 The Limitations of the Study

The study's main flaw is the paucity of research on and documenting of the function of local knowledge in reducing the risk of landslide disaster. The region is very young, and little study has been done, particularly in Asica.

## 1.7 Contribution of the Study

By conducting this study, value could be added by raising awareness of the critical role that Local Knowledge plays in disaster mitigation specially in Landslide disaster, as well as the issues related with the evolution and the transfer of these valuable local knowledge for future generations.

## 1.8 Chapter Summary

CHAPTER 1: Introduction

This introduction chapter serves as the orientation for readers, giving the overall background of the current studies including its purpose, scope and importance. Finally, this chapter suggest the objectives and the methodologies to achieve the goals of the study.

CHAPTER 2: Theoretical Framework

The purpose of this chapter is to illustrate the theoretical background for this particular study. It explains the important concepts, techniques as well as the review of the discovery from other researchers who have already published in the area of interest.

CHAPTER 3: Local Knowledge Adaptations to Landslides in mountain communities in Sri Lanka

This chapter has demonstrated the findings of the local adaptation practices in landslide disaster prone central region in Sri Lanka.

CHAPTER 4: Local Knowledge Adaptations on landslide Hazard in Depopulated Mountain Communities in Japan

This chapter has demonstrated the key findings from data analysis in Japan case studies. This chapter summarized the the consensus of Local Knowledge on landslide hazard in depopulated mountain communities in Japan.

CHAPTER 5: Local Knowledge evolution and transfer in a network of rural communities

This chapter comprises the findings of the the role of social capital in Local Knowledge evolution and transfer in a network of rural communities coping with landslide disasters.

CHAPTER 6: Conclusion

The final chapter comprises a conclusion, problems encountered during this study and further recommendations for future studies.

## 1.9 Conclusion

This introductory section provides the brief overview of the background, the research needs as well as the goals of this study. Furthermore, it explains the methodology in order to reach those specific goals. It then goes on to chapter 2 which will provide more comprehensive explanation about theoretical background.

# Chapter 2

# Theoretical Framework

## 2.1 Introduction

This chapter describes the theoretical framework of the study.Commences with a comprehensive examination of local knowledge and indigenous knowledge systems.Local knowledge has been ignored for a long time in favor of Western knowledge, which was believed to have all the solutions for coping with calamities and human issues. However, this is beginning to change as it is gradually becoming apparent that Local Knowledge is vital and that indigenous people possess a wealth of knowledge and experience that constitutes a valuable resource for the implementation of Disaster Risk Reduction. Local Knowledge has been used by several communities around the globe as a means of surviving natural disasters. There have been several accounts, following big disasters, of communities using traditional methods to defend lives and property.

This chapter will explain the significance and evolution of an Local / Indigenous Knowledge discourse. First, the concept of Local Knowledge, its qualities, and the actions that have developed it will be discussed. In addition, the chapter will provide an overview of best practices for using Local Knowledge. The chapter will conclude by highlighting the limits and obstacles encountered by Local Knowledge.

## 2.2 Local Knowledge

The term 'knowledge' indicates cognition; the possession of information or the state of having acquired it via experience or connection [38]. According to Zagzebski , knowledge is justified true belief that, by virtue of justification, differs from opinion or speculation [158].

Numerous terms are used to refer to Local Knowledge,including"traditional knowledge,ethno science,indigenous agricultural knowledge, indigenous knowledge, traditional environmental knowledge,indigenous technical knowledge,folk knowledge, farmers knowledge,rural peoples knowledge" [135].Recently, the term "Local Knowledge" has become a prominent topic in literary circles. However, defining Local Knowledge (LK) and creating research parameters was not always a simple task [133].Indigenous knowledge/traditional knowledge or local ecological knowledge can sometimes be defined as Local Knowledge [41,107].This section will examine how various scholars have interpreted the terms "Local knowledge / Indigenous Knowledge". Numerous meanings of Local Knowledge can be found in the past literature.

Indigenous knowledge (IK) is defined by Warren et al. [151] in a series of articles on indigenous knowledge systems.

"Local knowledge that is specific to a particular culture or that has grown around the particular situations of indigenous women and men in a particular region. It serves as a society's knowledge foundation and helps with communication and decision-making."

Indigenous Knowledge is defined by Mascarenhas [98] as the whole sum of knowledge and abilities possessed by the inhabitants of a particular geographical area, which enables them to maximize their natural environment. These talents and expertise are transmitted from generation to generation.The succeeding generation then modifies and contributes to the information and abilities that have been handed down, as a continual adaptation to environmental conditions. In an attempt to give them with survival skills, they transmit the corpus of knowledge in its entirety to the next generation. Indigenous Knowledge is defined by Rao and Ramana [125] as knowledge that is exclusive to a particular culture or civ-

ilization.These scholars contend that Indigenous Knowledge is distinct from the worldwide knowledge system produced by universities and research institutes. In addition, they contend that Indigenous Knowledge forms the foundation for local level decision-making in agriculture, health care, education, natural resource management, and a variety of other rural community activities. They assert that Indigenous Knowledge is transmitted verbally from generation to generation in many communities, and that Indigenous Knowledge varies in subject matter from Western knowledge.

Local knowledge has many knowledge levels; common indigenous knowledge is accessible to all community members regardless of age, gender, or social status; shared knowledge is held by many, but not all; whereas specialized knowledge is held by only few members, such as healers who have received special training [92]. It is unique and exists within communities indigenous to a particular geographic area [25, 75, 81, 90]. Additionally, local knowledge plays a vital role in providing the basic techniques and strategies for disaster risk reduction [75] by majorly contributing to early warning systems and weather forecasting management [42]. Local knowledge mainly involves tacit knowledge [66, 92], which resides in the human brain and cannot be easily acquired. The transmission of this valuable local knowledge from one person to another and from one generation to another is a key characteristic for ensuring sustainability of disaster-prone communities [80]. Richards [128] asserts that local knowledge is scientific because he emphasizes experimentation as an essential part of local knowledge.

"Local knowledge is knowledge that adheres to fundamental scientific theories but that, because it includes location-specific experience, enables improved risk assessment in production decision-making. This type of knowledge develops when locals do their own experiments or are able to draw conclusions from their experience and observations of natural experiments."

According to Flavier et al. [59], indigenous information systems are dynamic and are continuously changed by both internal innovation and experimentation and interaction with other systems. This ongoing process of exploration, creativity, and adaptation permits the blending of indigenous knowledge with science and

technology. According to Gupta and Patel, the many mechanisms of innovation that contribute to the generation of local knowledge include conceptual transformation, improvisation, accidental or serendipitous occurrences, communal or individual processes, sparking new metaphors, and humorous or amusing inventions. Despite the fact that several writers have tried to define "Local Knowledge," others have questioned and disagreed with the presented definitions. According to authors such as Naidoo (2007) [113], most definitions of Local Knowledge tend to reflect an overly romanticized conception of it. The most significant objection is that not all indigenous lifestyles have proved to be viable. On the basis of this reality, he believes that it is vital to keep in mind that Local Knowledge may not be a cure for all environmental issues, since it is also limited. Despite its limits, Naidoo recognizes the significance of Local Knowledge as a means of knowing and comprehending the world. Local Knowledge Systems and current Western science should be combined, according to Naidoo, to address the noted restriction. Another critique of Local Knowledge definitions is that they do not account for the consequences of modernization [113].

According to Ina Vandebroek, Local Information Systems (LKS) comprise the knowledge, beliefs, traditions, practices, institutions, and worldviews produced and preserved by indigenous and local groups, and are thought to reflect an adaptation strategy to the environment in which these communities exist.LKS have sometimes been perceived to be "traditional" with a negative connotation of being obsolete or outdated, and so of little usefulness to tackle difficulties of modern society [22], Others possess forward that the adaptability, usefulness, and worth LKS must be objectively evaluated and validated by science [18, 44].

Indigenous knowledge is ingrained in various communities around the globe, each with its unique environmental, social, cultural, economic, and political contexts. Despite the fact that this knowledge is inextricably related to these local settings, it is possible to transmit certain concepts and practices throughout communities to further promote disaster reduction. 'Traditional knowledge' can be defined as the practices, skills, and knowledge established, maintained, and adapted from generation to generation within a community, commonly forming part of its cul-

tural or spiritual identity [156]. On the other hand, 'local knowledge' can be referred to as the knowledge developed by individuals in each community over time and continued to grow. It is developed from repeatedly tested experiences over centuries, adapted to the local culture and natural environment, and embedded in community practices, relationships, and rituals [150]. Local knowledge is frequently described as distinct from the expert or scientific knowledge, often seen as formalized, explicit, rational, systematized, placeless, non-contextual, and transferable [23, 73]. Instead of recognizing the local knowledge as an essential approach to scientific knowledge, the two types of knowledge are often placed against each other and occasionally in normative practices that indicate a point of weakness on the section of local knowledge [73]. Moreover, local knowledge is primarily tacit and is often expressed through particular and created stories for better understanding, explanation, and making events in everyday life meaningful [79, 88, 89, 102, 127]. In summary, and for this article, local knowledge refers to the knowledge that individuals in each community have developed over time to reduce the risk embedded in the environment that they live, mainly because of natural disasters like landslides.

Local Knowledge is defined for the purposes of this research as including all technologies and practices that have been and continue to be utilized by indigenous and local people for livelihood, survival, and adaptation in a diverse range of circumstances. The concept acknowledges that Local Knowledge should be inclusive, including both information that has been utilized in the past and knowledge that is now being used by people to live, survive, and adapt to various situations. It also recognises that such knowledge is not fixed, but rather develops and changes dependent on the existing situations, and that it may both affect and be impacted by all of these variations.

## 2.3 Local Knowledge Systems

Local Knowledge and Local Knowledge Systems are two terms that are often difficult for people to differentiate and comprehend. Therefore, it is essential

that these two notions be distinguished. Local Knowledge Systems are defined by Barac [20] as the knowledge, innovations, and practices of indigenous and local groups and people from throughout the globe.Local Knowledge Systems are defined by Mapara [97] as the body of knowledge of the indigenous people of certain geographical places where they have lived for a very long period.
Local Knowledge Systems and Local Knowledge are clearly not the same thing, as seen by the definitions provided above. Local Knowledge Systems are a corpus of knowledge that incorporates Local Knowledge. In contrast, Local Knowledge is the application and use of the learned knowledge. Although the definitions vary, it is evident that they all highlight the same important traits. Local Knowledge Systems are distinguished by these features from all other types of Knowledge Systems. Local Knowledge Systems are considered in the context of this research as a collection of Local Knowledge bases, such as beliefs, ideas, practices, skills, tools, and other activities that have been passed down through generations to guarantee their long-term survival. Local Knowledge is considered a component of larger knowledge systems, which are collectively referred to as Local Knowledge Systems.

## 2.4 The Difference between Local Knowledge Systems & Western Knowledge Systems

Local Knowledge emerges via lengthy experiences in a particular context, culminating in knowledge that is based directly on evidence from these encounters. Agrawal [8] contends that, in contrast, scientific knowledge dissects and reorganizes obtained material in a manner that is often divorced from direct experience. In contrast to scientific knowledge, which is often affected by several external sources unrelated to the local culture or environment, Local Knowledge derives from inside the community. Local Knowledge is rooted in the individual community's reality and its cultural, moral, political, and cosmological ramifications. Scientific Knowledge takes pleasure in its universal applicability, ignoring the local environment [19]. As a method of preservation, distribution, and validation, sci-

entific knowledge is recorded, while Indigenous Knowledge is often shared orally, which better matches its dynamic and local nature.

## 2.5 Characteristics of Local Knowledge

Local knowledge is the information that individuals in a particular community have acquired and continue to acquire through time. Local knowledge has distinct characteristics.

### 2.5.1 Local Knowledge is oral

In the civilizations , information was usually transmitted orally. Oral narratives are used to educate skills, communicate cultural values, convey news, document family and community histories, and explain the natural world as part of the oral tradition, which is still highly valued today.Local Knowledge refers to the huge corpus of knowledge and abilities gained outside the official education system and passed orally from generation to generation [45]. It is communicated verbally and is not recorded or written down on any means. This implies that it is agraphic , since it is a body of information that is transmitted straight from one generation to the next via oral or verbal ways of learning [100].

### 2.5.2 Local Knowledge is generated within communities

The production of Local Knowledge occurs within communities. Baumwoll [21] confirms this by stating that the origin of Local Knowledge resides within the communities themselves. Furthermore, the author asserts that the community alone is responsible for the development process. The fact that Local Knowledge is developed inside communities allows every community to establish and construct its own Local Knowledge, which is specific to its particular environment and circumstances.

### 2.5.3 Local Knowledge is location and culture specific

Local Knowledge is exclusive to a particular culture, place, or civilization [45]. This indicates that each region has its own local expertise. This is reinforced by [100], who asserts that Local Knowledge is local, that is, knowledge that has been generated for a particular location. Local Knowledge in one domain differs from that in other others. The Mahikeng Local Knowledge is distinct from the Taung Local Knowledge. Local or regional residents select their own Local Knowledge, which is distinctive and beneficial to their continuous existence and survival in their specific community.

### 2.5.4 Local Knowledge is not systematically documented

Local Knowledge is not recorded systematically. As noted before, Local Knowledge is mostly transmitted orally by word of mouth. This implies that it is not scientifically documented and recorded in writing in the majority of situations. De Guchteneire et al. [45] claim that it is inferior to Western knowledge since it is not recorded and kept in a systematic manner. Since Western knowledge is written down, it is simpler to maintain and transmit it from generation to generation. Local Knowledge is difficult to obtain as a consequence of the absence of systematic recording; thus, few individuals are aware of it. This information is subject to oblivion since it is inaccessible to the general public. This may result in its extinction if its current owners die before passing it on to the next generation.

### 2.5.5 Local Knowledge is the basis for decisionmaking

Local Knowledge, according to Warren (1998), is the foundation for survival strategies and decision-making. This indicates that individuals gain this information to help them survive in their unique locale. Local Knowledge may be used as a cost-effective and long-term method to aid impoverished people in their daily battle for existence. This information may be used for survival in a variety of areas, including health, food preparation, agriculture, education, and disaster risk reduction [45].

### 2.5.6 Local Knowledge is concerned with critical issues of human life

Humans have recognized the need for harmony between the natural and social settings for generations. This is reinforced by De Guchteneire et al. [45], who observe that over many millennia, humans have developed knowledge and survival techniques that allow them to live in harmony with their natural and social surroundings. Maurial [100] claimed that Local Knowledge is comprehensive in the sense that it is formed and repeated through human interactions and their connection with environment. Maurial is reinforced by Koro (2005) [85], who argues that Local Knowledge is comprehensive since its epistemological framework and approach to reality are all-encompassing. Koro adds further that Local Knowledge is holistic because it is interwoven in the culture, languages, customs, and value systems of the people who have it, and so cannot be separated from them.

### 2.5.7 Local Knowledge is dynamic and based on innovation, adaptation and experimentation

Local Knowledge is a consequence of an ongoing process of exploration, creativity, and adaptation. This indicates that Local Knowledge changes and adapts in response to the specific environmental conditions. Local Knowledge may be merged and used with scientific and technological knowledge. Local knowledge reveals its vitality, flexibility, distinctiveness, and invention via the manner in which local or regional groups decide and build their own Local Knowledge. This characteristic is often distinctive and advantageous to their continuing existence and survival in their group [45].

## 2.6 Best Practices in the use of Local Knowledge

Local knowledge is a collection of facts that encompasses the full system of ideas, beliefs, and perceptions that individuals have about their immediate environment. This involves how individuals see and quantify their environment, solve issues,

and verify new knowledge.Local knowledge is sometimes referred to as indigenous knowledge, traditional knowledge, or local ecological knowledge [107]. It serves as the foundation of all environmental solutions for problems related to agriculture, health care sector, food preparation, natural resource management, education, etc. Local knowledge has many knowledge levels; common indigenous knowledge is accessible to all community members regardless of age, gender, or social status; shared knowledge is held by many, but not all; whereas specialized knowledge is held by only few members, such as healers who have received special training [92].

## 2.7 Limitations and Challenges of Local Knowledge

The previous debates have shown the advantages of Local Knowledge to the economic well-being of several indigenous populations. Nonetheless, it is essential to recognize that Local Knowledge contains limits and shortcomings. Multiple academics have asserted that Local Knowledge has a variety of limitations. A thorough examination of Local Knowledge, according to critics, reveals that not all Local Knowledge and practices are legitimate and ecologically sound. The majority of detractors assert that certain Local Knowledge methods have had negative results.

One drawback of Local Knowledge is that, despite the fact that such information systems have a degree of adaptability to ecological change, when change is exceptionally quick or extreme, the knowledge associated with them may become inappropriate and perhaps harmful under the new circumstances [70].

Indigenous beliefs, rituals, and practices may change with the evolution of time. This is the primary drawback of local knowledge, and it leads to inaccurate predictions about a specific issue. Occasionally, when compared to scientific understanding, locals' information may be incorrect [149]. This section has given an outline of Local Knowledge's limitations. It is evident from the debates that Local Knowledge has a variety of limitations that might have detrimental implications.

### 2.7.1 Disappearance

Local Knowledge is in danger of being lost because there isn't enough documentation and it's hard to keep this kind of knowledge safe. This is mostly because the majority of Local Knowledge practices are not documented. Orally and practically, the information is handed down from one generation to the next. Due to the absence of dependable records, it is easy for Local Knowledge to go extinct [109].

### 2.7.2 Marginalization

Local Knowledge faces the primary obstacle of marginalization. According to Ocholla [116], the marginalization of Local Knowledge has happened over time. According to Ocholla [116], marginalization refers to exclusion30,fe,ff0"80"94a condition of being left out or receiving inadequate attention. The assumption that Local Knowledge is rudimentary and antiquated, and hence of little value, is the source of marginalization. This way of thinking makes it hard to use Local Knowledge. Instead, western knowledge is used because it is seen as more advanced and better suited to a third-world country.

### 2.7.3 Lack of being Captured and Stored in a Systematic Way

Orally transmitted from generation to generation, according to De Guchteneire et al. [45], Local Knowledge runs the danger of not being systematically collected and archived.This could cause valuable pieces of local knowledge to become less useful or even disappear.

## 2.8 Vulnerability of Local Communities to Disasters

Vulnerability represents the physical, economic, political or social susceptibility of a community to damage in the case of a destabilizing phenomenon of natural or anthropogenic origin [33, 136].According to Schmidlin et al. [132, 136] "social

vulnerability to natural hazards is the potential for loss and is complex interaction among risk, mitigation, and the social fabric of a place". It is described as the social groups' vulnerability to the effects of risks and their capacity for proper recovery from them. The elements that affect social vulnerability are as follows [39, 136] :

- Lack of access to resources such as information, knowledge, and technology,
- Limited access to political power and representation,
- Social capital including social networks and connections,
- Beliefs and customs,
- Building stock and age,
- Frail and physically limited individuals, and
- Type and density of infrastructure and lifelines.

### 2.8.1 Conceptualisation of the term Vulnerability, Resilience, & Adaptive Capacity

The ideas of Vulnerability, Resilience, and Adaptive Capacity become essential to catastrophic risk reduction in disaster-prone societies.

The idea of resilience, which emerged in ecology applied to social and economic systems. Adger [6], for example, describes social resilience as the of communities or groups to withstand external pressures and unrest brought on by social, political, and environmental modification.Disaster resilience is the capacity of people, groups, organizations, and nations to cope with and recover from risks, shocks, or challenges without affecting long-term development possibilities.According to DFID [47] "the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses – such as earthquakes, drought or violent conflict – without compromising their long-term prospects."

Smit and Wandel have examined the subject of adaptability [137, 139]. Here, we'll

simply look at the concept's core characteristics. The term "adaptability" (or "adaptive capacity") 6 was first used in biology to refer to the capacity to adapt to a variety of environmental circumstances, i.e., the ability to survive and procreate in those circumstances. An adaptable trait, often known as a "adaptation", is a characteristic of an organism's structure, function, or behavior that is essential for maintaining adaptability. Adaptability is the state of being adapted [51]. Adaptability is not a general trait; rather, it pertains to a particular environment or set of conditions, and many organisms, populations, or species are adapted to various habitats.

Vulnerability is a concept using in different research traditions [77], but there is no consensus on its meaning. Depending on the research area, it has been applied exclusively to the societal subsystem, to the ecological, natural, or biophysical subsystem, or to the coupled SES, variously referred also as target system, unit exposed, or system of reference. [5] examines the evolution of approaches to vulnerability originated in the social and the natural sciences. He concludes that vulnerability is most often conceptualized as being constituted by components that include exposure to perturbations or external stresses, sensitivity to perturbation, and the capacity to adaptation.

### 2.8.2 Linkages between Vulnerability, Resilience, & Adaptive Capacity

In the fields of social-ecological systems, disaster risk science, and global environmental and climate change research, vulnerability, resilience, and adaptation are three essentially interrelated concepts.The relationship between vulnerability, resilience, and adaptive capacity is still not well expressed as shown in (Figure 2.1). According to some researchers, resilience is an integral part of adaptive capacity (Figure 2.1 a) while others view adaptive capacity as a main component of vulnerability (Figure 2.1 b). A third perspective sees them as nested concepts within an overall vulnerability structure (Figure 2.1 c) [103].

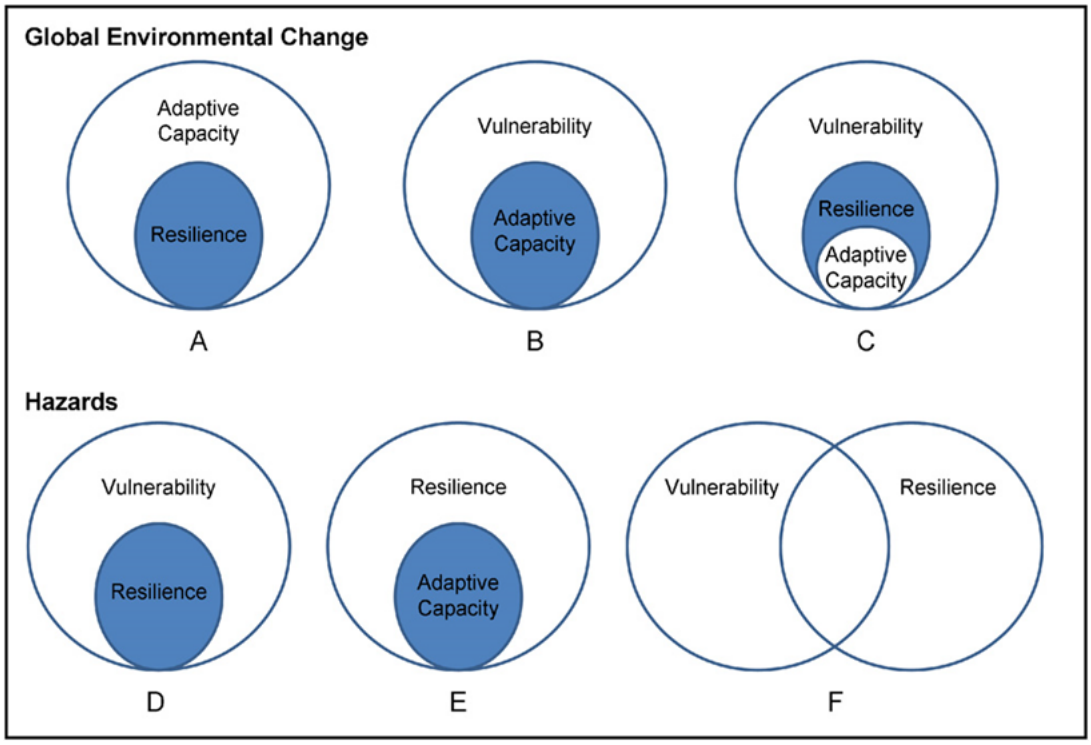



Figure 2.1: Linkages between vulnerability, resilience, and adaptive capacity [103]

The Adaptation also means as an adjustment in a system's behavior and characteristics that enhance the level of resilience. For this study, adaptation take as a concept within the level of resilience. The level of adaptation enhancing the resilience disproportionately reduces the level of vulnerability. Therefore, third perspective was incorporated for this study and its sees adaptation and resilience as nested concepts within an overall vulnerability structure (Figure 2.1 c).

### 2.8.3 Factors impacting on Vulnerability

Local communities all around the world are particularly vulnerable to disasters because of the vulnerability brought about by their social, cultural, environmental, economic, political, and physical conditions.In addition to these, their age, gender, ethnicity, and physical and mental health all affect how vulnerable they are to disasters.According to Baumwoll [21], social vulnerability describes how catastrophes affect a society's social structure and vice versa. The most frequent social conditions that make local groups more vulnerable are poor access to housing, healthcare, and education.A society's natural surroundings and the effects of en-

vironmental deterioration are referred to as the local community's environmental vulnerability [21].

## 2.9 Social Capital of the Local Communities

### 2.9.1 Conceptualisation of the term Social Capital

Social capital addresses the value of social connections in terms of competitive advantages derived from resources embedded in the social structure [55, 144]. Woolcock [155] defined social capital as, "encompassing the norms and networks facilitating collective action for mutual benefit."

### 2.9.2 Dimensions of the Social Capital

Nahapiet and Ghoshal [112] reported three social capital dimensions: structural, cognitive, and relational (Table 2.1). The structural dimension includes network ties, which are associated with specific actors. Ties are fundamental aspects of social capital because the social ties network of an actor creates opportunities for social capital transactions [77, 91, 92]. The configuration of a network structure determines the pattern of linkages among network members. Configuration elements, such as hierarchy, density, and connectivity affect the flexibility and ease of knowledge exchange through their impact on the extent of contact and accessibility among network members [92,144]. Furthermore, network stability is defined as the change in membership in a network. A precarious network may limit the creation of social capital opportunities because when an actor leaves the network, ties are broken [92, 144]. The cognitive dimension represents the resources that provide shared meaning and understanding between the network members, and shared goals represent the degree to which network members share a common understanding and approach to achieve network tasks and outcomes. Members of an intercorporate network usually work towards a common goal. Depending on the network type, the tasks and outcomes regarding clarity and definition may vary. Furthermore, shared culture refers to the degree to which norms govern relationships. This factor is similar to tie modality, which is "the set of institutionalized

rules and norms that govern appropriate behavior in the network. While these are sometimes spelled out informal contracts, most often they are simply understandings that evolve within the dyad and the network" [144]. The relational dimension focuses on direct ties between actors and the relationship instead of structural outcomes of interactions. Previous literature suggests that these relationships can be in the form of bonding, bridging, and linking social capital [27,74]. Bonding social capital connects individuals with a relatively high degree of homogeneity in terms of their socio-financial position and demographic characteristics within the community (for example, family, relatives, kinship groups) [30, 87, 114, 119, 131, 134]. On the other hand, bridging social capital refers to connections between people who are not family, relatives or kin, but have similar financial status and political influence [87, 114]. As a result of bridging, community members from across social divisions within a neighbourhood keep close relationships, irrespective of their ethnicities, geographical or occupational backgrounds. Moreover, linking social capital refers to connections between groups and people in positions of power (whether due to political position or financial resources) and includes vertical links to formal institutions, such as governmental organizations [87, 114, 119]. Among those different types of relationships, there are many dimensional factors such as trust, norms, and identification; but this study has focused only on trust. Trust is a critical factor that affects inter-firm knowledge transfer and creation [144].

| Structural dimension | Cognitive dimension | Relational dimension |
|---|---|---|
| Network ties | Shared goals | Trust |
| Network configuration | Shared culture | |
| Network stability | | |

Table 2.1: Dimensions of social capital, Source: Nahapiet and Ghoshal 1998 [112].

### 2.9.3 Significant of Social Capital in Disaster Risk Reduction

The importance of social capital has been discussed in different disciplines – i.e. social science, economics, environmental management etc. Moreover, different researchers have identified social capital as a critical component of community resilience in the disaster risk reduction process [10,11,13,101,114,115]. Literature has focused on the dominance of social networks in disaster recovery [91], the positive and negative influence of social capital in disaster response and the need for context-specific cultural understanding of disaster response [10,64,134]. This is because social capital in disaster management appears to have differential effects for different people, depending on their particular socio-cultural context [11,134,143]. Entoh Tohani [143] investigated the role of social capital in a community that is highly vulnerable to eruption, and the study highlights that social capital covering values and norms, commitment, trust, networking and sharing of information or knowledge provides benefits in the form of increased community awareness of disaster, social solidarity, and disaster knowledge of the villages [143]. Sarita Panday's [28] study, focusing on the strength of social capital in disaster recovery based on the Nepal earthquake in 2015, emphasizes how bonding, bridging and linking social capital can influence the disaster recovery stage. Ananda Y. Karunarathne [82] investigated the evolution of social capital legacies in response to flood disasters in rural and urban areas in Sri Lanka. The findings reveal that social capital had evolved at different flood inundation phases, and played a vital role in recovering village livelihoods affected in past disaster events. Thus, bonding, bridging, and linking social capital helped reduce the adverse effects of past floods. Yong Lu etl [93] analyzed the information exchange in virtual communities under extreme disaster conditions, and this research has found that structural capital increases information quantity, whereas relational capital and cognitive capital increase information quality. However, some scholars argue that the inclusion of social capital into network analysis and knowledge transfer has not been discussed in the past literature sufficiently [140]; and also there are relatively few studies conducted in rural regions of developing countries [48,74,144]. Furthermore, none

of the researchers have focused on the context of a rural community in a landslide disaster risk environment. In the Sri Lankan context, the unavailability of literature is critical, as this limits the opportunity to examine the multilevel view of social capital, and how knowledge is acquired and transferred in different social networks [9].

The evolution of knowledge and their subsequent transfer is an essential factor in preserving these valuable local knowledge systems. Many studies have been conducted to identify the adoption of local knowledge to address climate change, drought, typhoons, etc. [25]. However, few studies exist on the adoption of local knowledge for landslide disasters [42, 90]. Despite these positive attributes, the possibility of integrating traditional and locally derived mechanisms into formal disaster risk-reduction strategies is low. Therefore, understanding these conventional disaster risk reduction mechanisms and the process of knowledge transfer is critically required [50, 66, 95]. However, few researchers have focused on analyzing the community's social networks, social capital, and disaster-related local knowledge transfer mechanisms in communities that are sustainably adapted to disasters [82, 93].

## 2.10 Local Knowledge in Disaster Risk Reduction

### 2.10.1 Introduction of Local Knowledge in Disaster Risk Reduction

Local knowledge mainly involves tacit knowledge [66, 92], which resides in the human brain and cannot be easily acquired. The transmission of this valuable local knowledge from one person to another and from one generation to another is a key characteristic for ensuring sustainability of disaster-prone communities. The contribution of indigenous local knowledge is the effective and useful disaster risk reduction intervention for identifying, assessing and monitoring disaster risks and enhancing the early warning for disaster risk reduction activities at the local level.

Local knowledge contributes the large body of knowledge and skills developing at the outreach of the formal educational system [15]. The practice of using local knowledge is embedded in the society as a culture for long period of time. It helps and provides the basis for planning and decision-making for communities as in food securing, human and animal health, educational and natural resource management.

### 2.10.2 Value of Local Knowledge in Disaster Risk Reduction

Numerous justifications for the importance of local knowledge in disaster risk reduction have now been developed as a result of recent breakthroughs in the disciplines of local knowledge and disaster risk reduction. Baumwoll [21] lists four main justifications for the need of local knowledge in disaster risk reduction. We'll talk about and explore each of the four reasons below.According to the first argument, there are numerous companies that have tactics or know-how that can be used to lower disaster risk.The second statement is that local knowledge increases the engagement of the affected communities, enabling them to play a leadership role in disaster risk reduction.The expertise found in local knowledge enhances project implementation process, according to the third argument [21]. Understanding local customs and circumstances comes from respecting and accounting for local knowledge.The last statement is that non-formal methods of disseminating indigenous knowledge serve as a successful model for future training in disaster risk reduction [21].The four reasons listed above demonstrate how local knowledge is valuable in reducing disaster risk and is essential in disaster response. The chapter comes to a close by going through a few instances where indigenous knowledge has been used to reduce disaster risk.

## 2.11 Recent studies on local knowledge in Disaster Risk Reduction

The strategies and approaches for the preparation of disaster prevention, mitigation, and rehabilitation in developed countries by public or non-governmental agencies are unsuccessful to reduce the vulnerability effectively [96, 110]. The proper establishment and implementation of disaster management need a high degree of adaptability to the local situations. Culture, traditions, and customs play a crucial role in the success or failure of disaster management [83]. On the other hand, it is necessary to take into account the cultural context in affected localities and areas. In order to develop a suitable user-friendly package, the customs, traditions, local practices, and ethnic compositions in an area should all be considered [67, 83, 101]. In this situation, there are gaps between the technical information generated from the specialists and the information received from the local communities in the form of risk-based knowledge resulting from the previous disasters and familiarity with the environment, which can be vital for locally appropriated solutions [58]. Local knowledge can be defined as beliefs, a set of information, mental abilities, and practices, developed from the adaption practiced through generations by personal interactions and locally 'generated through observations of the local environment' [24]. It becomes the foundation of all environmental solutions for problems related to agriculture, the health care sector, food preparation, natural resource management, education, etc [25, 75, 81, 90]. In addition, local knowledgeplays an essential role in contributing the basic techniques and strategies by providing early warning systems and weather forecasting management for disaster risk reduction [42, 75].

In Japan, the significance of indigenous/local knowledge in disaster risk reduction was emphasized by scholars related to different disaster events during past decades. For example, a story is told and believed to have been handed down by an ancestor who lived in the Sanriku region of Japan, a tsunami-prone area that saved many lives in the Great East Japan Earthquake in March 2011 [161]. These phenomena describe how local knowledge is vital in disaster risk reduction among commu-

nities applying local knowledge to prevent disastrous events. In addition, many researchers have proved local knowledge as a vital factor of community resilience in the process of disaster risk reduction [11,13,104,115]. Furthermore, past studies have emphasized the function of local knowledge in disaster recovery [91] and the need for context-specific cultural understanding of disaster response [12,64]. Nevertheless, the importance of local knowledge in disaster management was discussed and documented [124], but the effect of the consensus of the landslide-related local knowledge in a depopulating community is still not correctly identified, especially in the population-depleted mountain communities in Japan. Hence, the lack of theoretical research over the critical concepts related to landslide disasters with local knowledge motivated the present research.

## 2.12 Conclusion

This Literature found the basic concepts related to local knowledge adaptation into natural disasters. The communities are rich with an experience of such places and they have sense of the area rather than the decision-making bodies in the governance. The local communities are having anticipated knowledge for upcoming disaster with their sensitivity of the place and surrounding their environment. It has potential together with scientific knowledge; to save lives and huge economic losses such indigenous knowledge can make a sound foundation for preventing disasters and livelihood damages in disasters. But the case is the governance bodies are not connecting to with the local community when they manage the disaster. Mountain settlements all across the world have recently become more susceptible to natural disasters. This study focuses on discovering the local knowledge already exist in those communities that support reducing landslide risk.

# Chapter 3

# Local Knowledge Adaptations to Landslides in mountain communities in Sri Lanka

## 3.1 Introduction

### 3.1.1 Landslides risk in Sri Lanka

Landslides, floods, and droughts have been cited as the most common and dangerous types of natural catastrophes in Sri Lanka in recent years. As the primary consequence of global warming, rainfall patterns have altered dramatically over the past several years, and this change has a direct impact on how frequently landslides occur and how they affect ecosystems [126].The majority of and most significant landslides occur in central hilly terrains. The central hills region's Badulla, Nuwara Eliya, Ratnapura, Kegalle, Kandy, Matale, and Kalutara Districts, as well as the southern hills' Matara, Galle, and Hambanthota Districts are considered to be landslide-prone areas, with about 20,000 km2 (37.7 %) of the total land area being extremely vulnerable to landslides. Landslides are a key problem for the nation's hilly regions due to the slow but steady increase in demand for the development and extension of human settlements [72]. Landslides are happening more frequently and at a faster rate. According to estimates, there are currently

1 to 2 landslides every square kilometer. It is typical for one or two landslides or cutting failures to occur after every storm. In Sri Lanka, landslides can be caused by both natural and artificial factors [42]. The primary landslide records up to the year 2016 are depicted in Figure 3.1. Disasters caused by landslides have emerged as the greatest threat to nations like Sri Lanka. To ensure the sustainability of developments and reduce the likelihood of landslide-related disasters, it is crucial to identify the best methods for reducing landslide risk connected with the terrain.There are primarily three categories for landslide risk zones in Sri Lanka: high, moderate, and low landslide risk zones. The likelihood of a large-scale landslide occurring in high-risk areas is considerable, and according to records from the area that recently experienced one, it completely obliterated all habitation without leaving any objects behind. Additionally, moving to a different place is the sole option for residents of the impacted areas with a significant landslide risk. However, by employing efficient landslide mitigation measures, locations with a moderate level of risk might minimize the degree of vulnerability.

### 3.1.2 Contribution of local knowledge in disaster risk reduction

Indigenous local knowledge is a valuable and effective disaster prevention approach for detecting, evaluating, and assessing catastrophe threats as well as improving early warning for disaster mitigation initiatives at the local level. Local knowledge adds to the vast corpus of knowledge and skills emerging at the margins of the official education sector [15]. Utilizing local knowledge is a long-established practice that has been ingrained in social and cultural context. It supports and offers the foundation for planning and decision-making for communities, including in the areas of food security, human and animal health, educational opportunities, and management of natural resources.

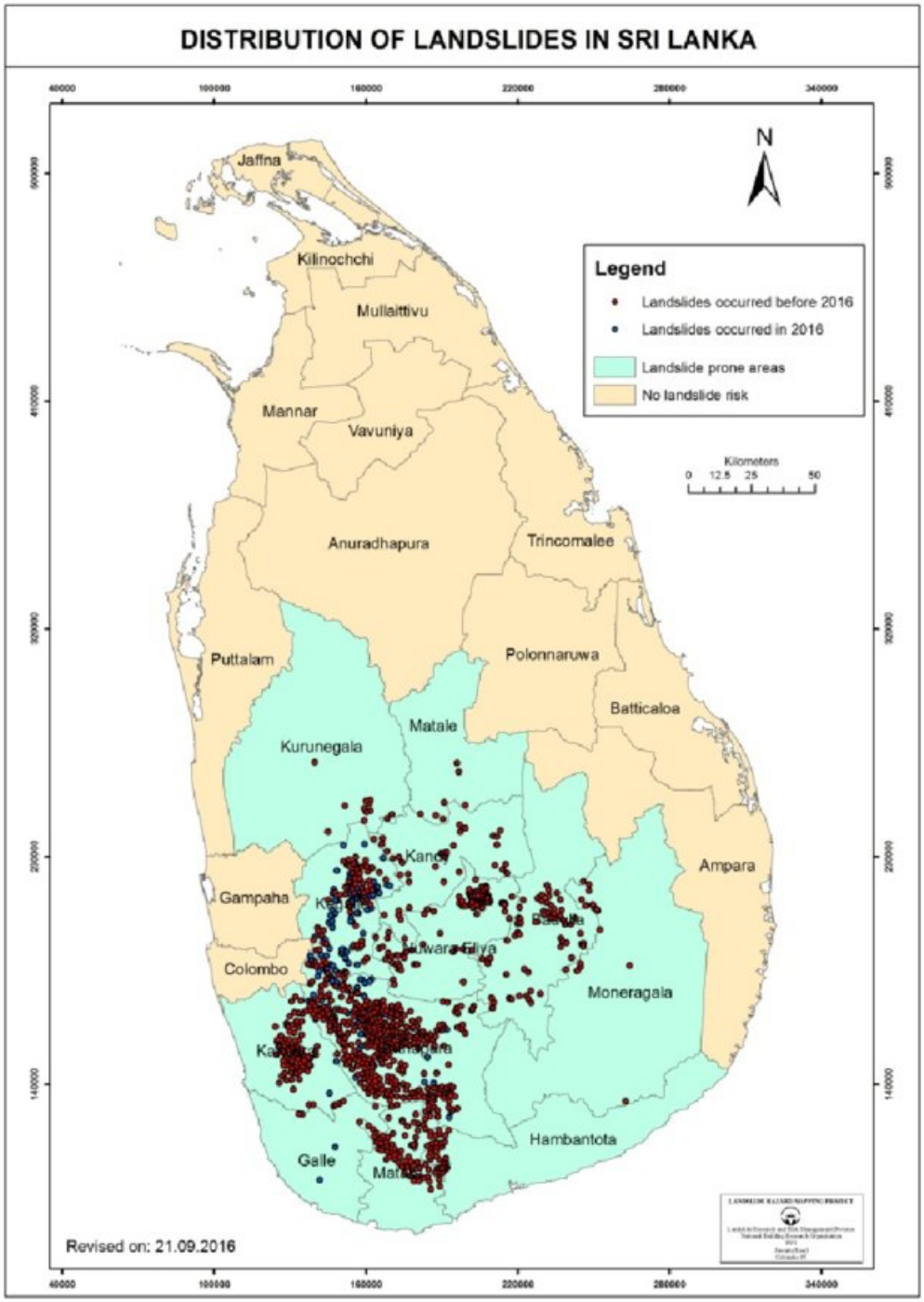



Figure 3.1: Distribution of occurred landslides in Sri Lanka

## 3.2 Sub-objective

The sub-objective of the section is to identify, investigate and evaluate the local adaptation practices in landslide disaster prone central region in Sri Lanka.

## 3.3 Study Area

### 3.3.1 Selection of Case Study

The present study focuses on two communities located in the Matale and Nuwara Eliya districts in the central mountainous region of Sri Lanka. The districts are majorly surrounded by central mountain ranges, which are young, have unstable geology, steep slopes, and climate that is difficult to predict. Due to the meteorological, geographical, and geological conditions, and socio-economic characteristics, some regions are highly susceptible to landslides. Therefore, this study selected two communities residing in the Etanwala and Mandaramnuwara villages, which have a long history of landslides, and are located in the Grama Niladari division.

### 3.3.2 Reasons for the selection of the case studies

Matale and Nuwara Eliya surrounded by mountain ranges. The mountain ranges are young with an unstable geology, steep slopes, and climate that is difficult to predict. Because of that those areas are more susceptible to the natural disasters [15].

Matale and Nuwara Eliya are the two vulnerable district for disasters out of ten hazard prone district [152]. In past two decade severity of landslide disasters were increased in highland region in Sri Lanka. Landslide disasters in moderate level hazard in both Districts. So that mitigation measures are highly important to reduce vulnerability of the effected people. As a result there can be found some of the local adaptations they have use to live with disaster. They have many experiences about their surrounding environment; understand the changing environment with reasonable matters. Further the area people who are very experience with disaster situations and they have knowledge types such as traditional, technical and historical knowledge about the natural disaster. Therefore they are most probably use better, faster and safer ways to respond to disasters with individual practices and also combine with different level of local community groups.

The research study was conducted in one geographically isolated village named

'Etanwala' in Matale District and moderately isolated village named 'Mandaramnuwara' village in Nuwara Eliya District. It is due to different types of landslide disasters to find out different local knowledge adaptations in of different disaster contexts. Moderate level risk area was selected to observe the adaptations. Because in moderate level hazards areas' settlements still remain. People were not going resettled another place, livelihood patterns are basically depending on the surrounding environment. Therefore, based on above all factors the two villages from central hilly region were selected as case studies.

This study considers various aspects during the selection of case studies. It primarily assumes that the communities have already adapted to landslide disasters. Multiple reasons exist for considering this assumption. First, both communities have a history of landslides, but several generations still reside in the areas and have not changed their geographical locations. Second, spatial and non-spatial local adaptation measures for landslides were identified in both the communities. Therefore, this study assumes that Etanwala and Mandaramnuwara villages are sustainably adapted to landslide disasters.

### 3.3.3 Introduction to Case study 1 – *Etanwala village*

Etanwala village is administratively named as the Etanwala Grama Niladari division within the Matale District. Although landsides are primarily associated with the mountainous regions, they can occur in areas of generally low relief. Matale district is one of the regions comes under the central part of the island consist of high mountain ranges. Matale is consisting of significant topographical features, climatic conditions and wide range of minerals. This region geographically coordinates between 7° 28' 18' North, 80° 37' 28' East. Average area temperature 26 °C to 30 °C and it vary due to the climate variation in the year. Matale is a region with a significant rainfall. Even in the driest month there is a lot of rainfall and the area annual rainfall is 1110 mm to 1400 mm. Old landslide deposits are activating during South West Monsoon (Table 3.1).

Most of the part has Red Yellow later sols soil condition [15]. Due to its' geographical, geological constitution and socio-economic characteristics some areas

| GND Name | Date | Reason | Affected Families | Affected people |
|---|---|---|---|---|
| Polwatta | 02/11/2006 | Rock Fall | 31 | 120 |
| Dankanda | 24/03/2006 | Rock Fall | 10 | 30 |
| Rattota | 29/12/2006 | Debris Fall | 2 | 5 |
| Pandiwita | 12/11/2005 | Rock Fall | 7 | 25 |

Table 3.1: Landslide history of the Matale district

are susceptible to the impacts of landslides. The smallest administrative regions named as Grama Niladari Divisions ( GND ) and each GND consist of one or two villages. There are mainly 545 GN Divisions comes under this district. Level of landslide risk is slightly varied with the topographical and geological features. Around 40% of the region under moderate level landslide risk zone.

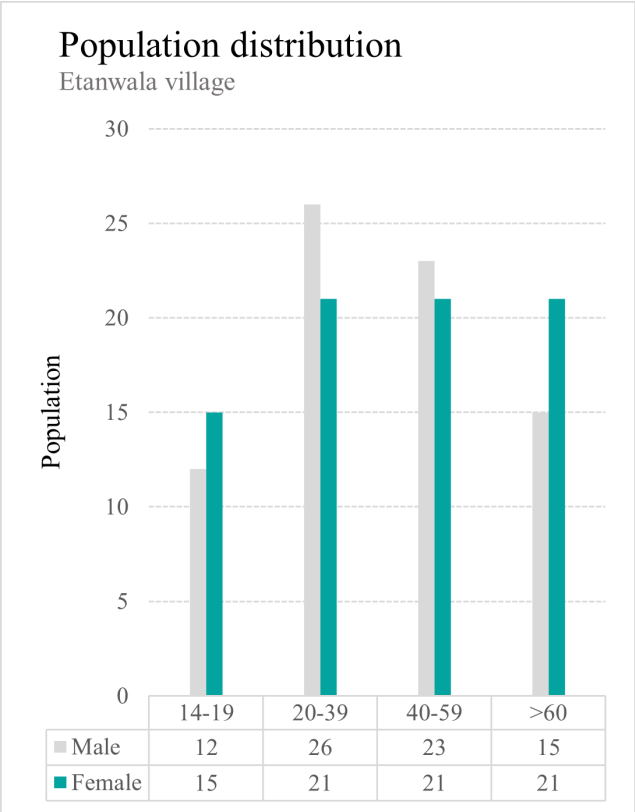



Figure 3.2: Demographic profile of the Etanwala village

The total village land area is 42 km2. The total population of the village is 154 individuals, with 59 families living in 48 houses (Figure 3.2). The village

is approximately 11.76 km at a direct distance and 29.1 km by road from the city center of the nearest town, Rattota. However, its distance from the main city, Kandy, is 26.16 km directly and 64.1 km by road (Figure 3.3). According to the distribution of land uses, more than 50% of the village is surrounded by forests. The community residing in this village is predominantly agricultural, mainly engaged in rice and vegetable cultivation. More than half of the area is cultivated (approximately 84%), approximately 14% of the area is covered with forests, and only 2% is covered with settlements(Figure 3.3). Kalu Ganga Black River is the primary water source used for cultivation and domestic purposes. The river separates the village from other areas and connects the village by a 3 m bridge. Furthermore, more than 90% of the village area is susceptible to landslides according to the landslide risk classification performed by the National Building Research Organization, Sri Lanka; additionally, two small-scale landslides have occurred in the village. Debris flow and rockfall landslides are the two types of landslides that can be expected in this area.

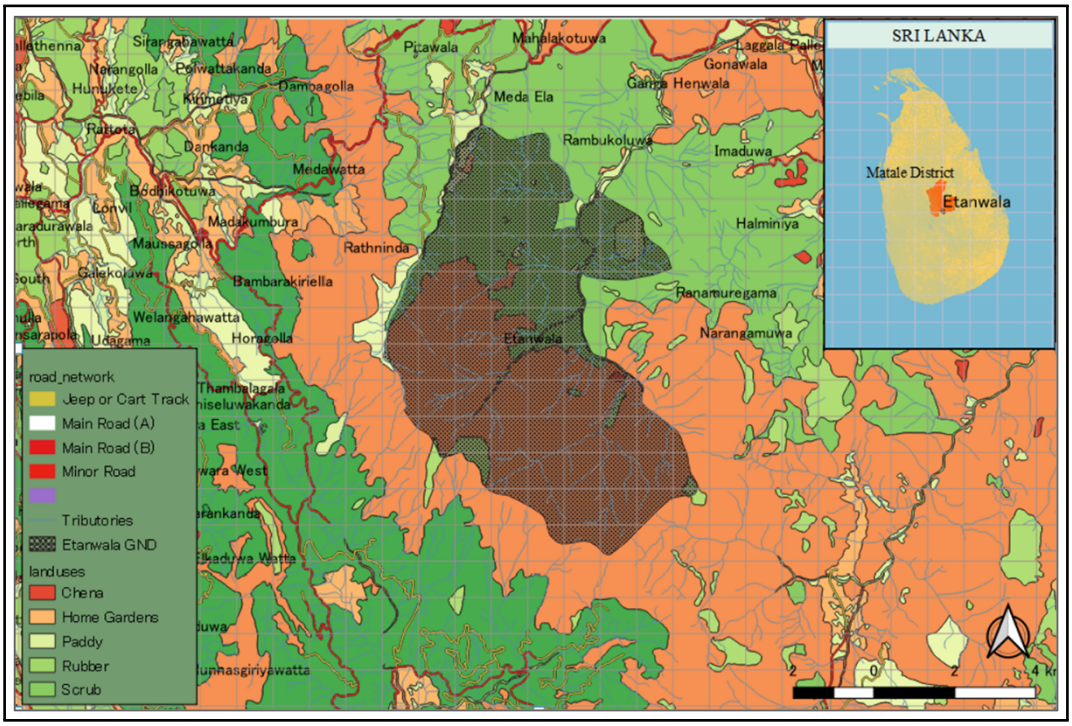



Figure 3.3: Landuse map of the Etanwala village

### 3.3.4 Introduction to case study 2 – *Mandaramnuwara village*

Mandaramnuwara village in the Nuwara Eliya District was selected as the second case study. It is located 16.81 km at a direct distance and 24.9 km by road from the city center of the nearest town, Hanguranketha. Moreover, it is 34.55 km at a direct distance and 56.7 km by road from Kandy (Figure 3.4). The total village land area is 37 km2. The total population is 323 individuals, with 112 families residing in 89 houses. More than two-thirds of the village area is covered by forests. According to the distribution of land uses, more than 70% of the area is surrounded by forests (Figure 3.4). Sudu Ganga River is the primary source of water used mainly for domestic purposes and cultivation. According to the landslide risk classification by National Building Research Organization, more than 80% of the area is susceptible to landslides. Nearly two small and one medium-scale landslides have occurred in the village. Debris flow type of landslides can be expected in this area.

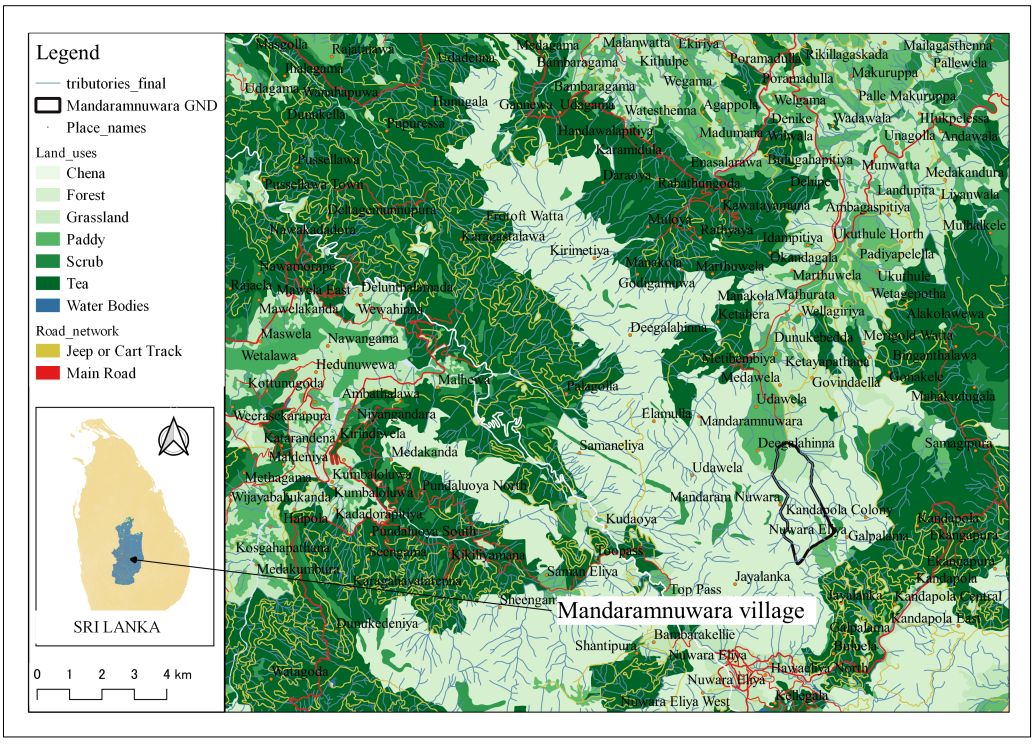



Figure 3.4: Landuse map of the Mandaramnuwara village

## 3.4 Data Collection and Analytical Methods

Interviews of the key informants, group discussions, and household surveys were conducted in both the village communities to collect data on social ties, and evolution and transfer of a constituent of traditional knowledge. Key informants were traditional knowledge holders or village leaders. The initial community meeting was done with the responsible government officers appointed to each village, identified as 'Gramaniladari ': as in any qualitative study, it is a requirement that the researcher approaches the region and its people. Accordingly, two field visits were conducted in this study; and a preliminary field survey was conducted in early 2018. A household questionnaire was developed, based on the data obtained from the preliminary visit, to understand the network ties in knowledge sharing.

### 3.4.1 Sampling

Questionnaire survey was undertaken to systematically obtain in – depth empirical data to find out the local level adaptation into landslide disaster. Stratified random sampling method which provides greater accuracy than a simple random sample of the same size was employed to select the respondents for questionnaire survey. Strata were formed based on different age categories and respondents were randomly selected from the moderate level disaster prone areas. Direct observations, documentary reviews (i.e. newspaper records, archives papers, video documentaries) and in-depth interviews were undertaken to verify and elaborate the findings of Questionnaire survey. Photographs, sketches and field notes were used to record the empirical observations on community practices, adaptation methods and their behaviour to natural disaster. That information is used for discussions as to prove findings and explaining some of the statements given by the local community. Mind mapping was used parallel to the questionnaire survey to interpret how local people identify vulnerable areas, roads and safer places based on their local knowledge and past experience.

Instead of using random or stratified sampling technique, snowball sampling method was used to select respondents for Key Informant Interviews. It is a non-probability

sampling technique in which existing study subjects collects future subjects from among their associates. 'Snowball sampling applies recommendations to select people with the specific range of skills that has been recognized as being useful.' Key Informant Interviews were undertaken with the experts in the field, to discuss about the existence of local knowledge adaptation into landslide disaster.

### 3.4.2 Key Informant Interviews

After the initial community entry meetings in both communities, key informants were selected using a snowball sampling approach. Initially, the discussion was held with the 'Gramaniladari', appointed as a community officer in this village. After explaining the research purpose thoroughly, he was requested to list a few candidates for further interviews. A preliminary interview was conducted with one village elder named by the government officer, during the initial visit. The interview followed the same procedure to approach the second village. A detailed interview series commenced, with the persons listed by the community officer from the two villages. Nevertheless, at the end of each interview, the interviewees suggested the names of another suitable individual to have an interview with. Finally, the total data were collected from 15 detailed interviews apart from the initial community meetings. Discussions focused on disaster knowledge evolution, modification, and transmission within the community.

### 3.4.3 Household Questionnaire Surveys

For this study, the 80 sample population was selected using the snowball sampling technique [43] and conducted a questionnaire survey. The sample included four categories of villages based on their age, 10 candidates from 12 to 19 years age group, 22 from 20 to 39 years age group, 25 from 40 to 59 years age group and 23 candidates from more than 60 years old group who are dwelling in this village. Reason for carrying out the micro level study was to ascertain village's utility of their local knowledge on landslide disaster risk reduction. Since it does not completely capture all features of the local adaptations, semi structured interviews were conducted with selected elders as well as with some relevant government

officers. Percentage analysis was used to analyze the data.

### 3.4.4 Data Analysis

The analysis has been carried out in using three main techniques. Percentage analysis was used to analyse the data related to different local knowledge adaptation practices and how the level of awareness varies with the different age categories. Social network theory is the study of the structure of the relationship between individuals within pre-defined environment as well as the behaviours of the individuals embedded in the network and the characteristics of the whole network. In this study, Social network analysis was undertaken to evaluate the Local Knowledge creation and transmission within selected two communities. Grounded theory is a systematic methodology in the social sciences involving the construction of phenomenon through methodical gathering and analysis of qualitative data. Grounded theory approach was used to carried out the analysis in in-depth interviews.

## 3.5 Empirical Findings

This section describes how the empirical research was conducted and provides and examines the findings of the study.

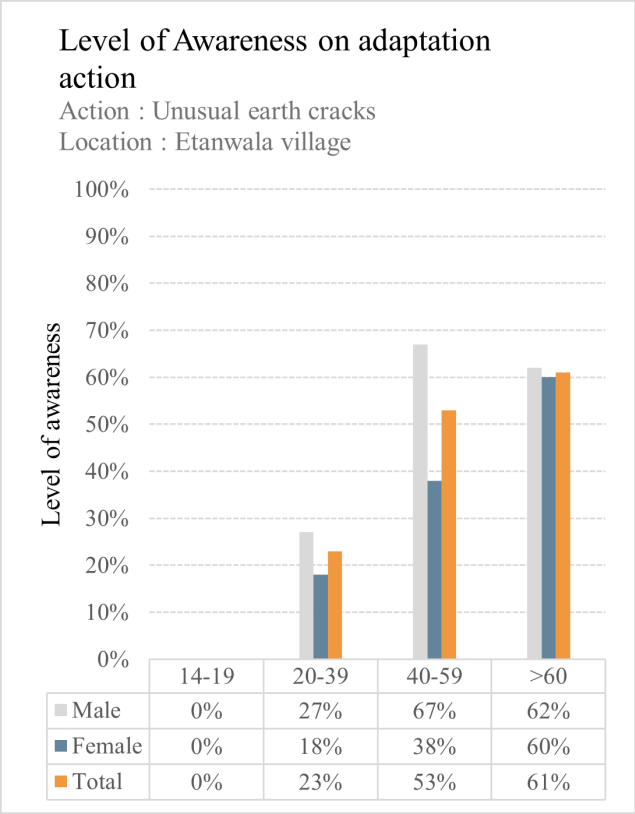
### 3.5.1 Various Adaptations for the Landslide Disasters

#### 3.5.1.1 Early signs for Landslides

Nowadays, disaster prediction methods are effective and efficient with the most advanced technologies. But, the developing countries are still facing with the difficulties of accessing high technologies for disaster prevention program. In this case, the local knowledge regarding the early signs is very reliable and practical solutions for the local people. In this research, two main types of early signs regarding with the disaster prevention used by communities for the landslides are identified. The first type is unusual earth cracks which can be easily observed by

checking the newly occurred cracks on ground. Using the above knowledge of early signs, local people can assume the area as high potential to landslides. The second one, continuous heavy rainfall, can make the changes to the ground water table by increasing the risks of severe landslides. The local people get cautions for the risks of landslide as soon as they notice the heavy continuous rainfall phenomenon for three or four days.

Unusual earth cracks are the one main early sign that they use for pre-identification of landslide events. This method specially mentions in some articles published by the government authority in order to increase the awareness. However, the awareness on this varies among different age categories. Between the age of 14 to 19, there is very low percentage which shows that there is no awareness in landslide events. Similar to the previous age group, there is very few awareness in the age between 20 to 39. On the other hand, the age between 40 to 59 indicates the very high awareness in landslide events. The last group having the age of more than 60 also indicates the high awareness of landslide risks




| | 14-19 | 20-39 | 40-59 | >60 |
|---|---|---|---|---|
| Male | 0% | 27% | 67% | 62% |
| Female | 0% | 18% | 38% | 60% |
| Total | 0% | 23% | 53% | 61% |

Figure 3.5: Unusual earth cracks used as a Early sign, (N = 80)

#### 3.5.1.2 Warning system based on temple bell

The villagers have strong beliefs in cultural system. They all inherited all the beliefs and behaviours within their group and respect them. Temple is one of the most important and sacred place as religious beliefs for the group to deliver the important messages and decisions to them. Therefore, they use temple bells to give early prevention signs by ringing the bells. As the temple is located at the centre of the area, the people can get easy access to the place and escape from the risks of the disaster when they notice the sound of the bells for emergency disaster prevention case.

This practice has derived from the culture since long time ago. Almost all the people in the community positively engage with the religious activities which conduct in the temple. Therefore, all age categories have full awareness on this respect. This community always depends on this practice on emergency. For the landslides and other type of disasters, they use the same measure to pass the warning messages. Every person in the community immediately comes to the temple as soon as they receive the warning message. The location of the temple is the key point for the village and is necessary to locate at the safest area of the village.

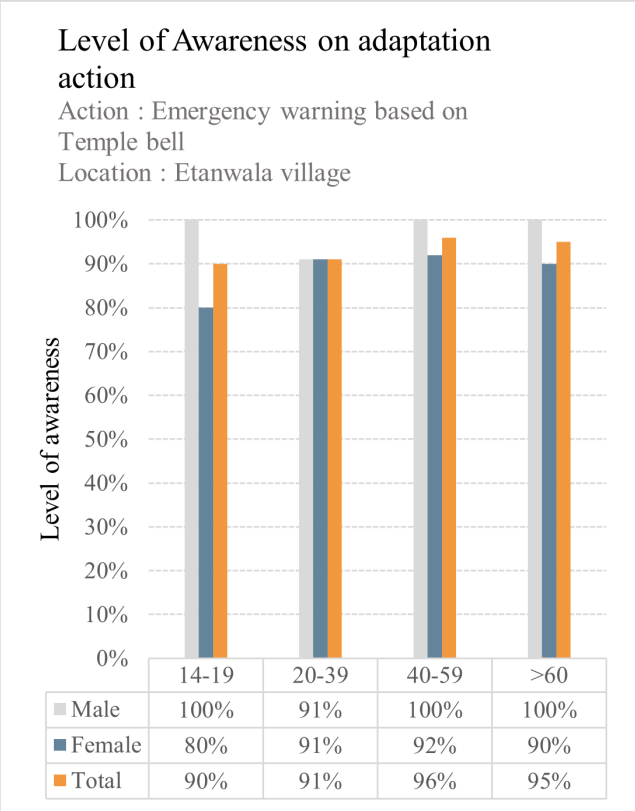



Figure 3.6: Emergency warning based on Temple bell, (N = 80)

They can finally evacuate to the shelter after arriving to the temple before the disaster. Therefore, this method is very effective among the community because everyone follows this practice as it derives from the culture. There was one regretful incident occurred in the recent past concerning with the improper warning system. There was one severe landslide happened based on the heavy rainfall. Before the incident, the National Building Research Organization issued a warning message through the social media to evacuate from high risk zone. However, the people in one village were not accessible to obtain the message due to the electricity failure because of the heavy rainfall.

The government officer who had the responsibility to pass the message went to that village and passed the message to each house. During passing the information, the landslide disaster happened, and unfortunately, he died in that incident. If the government authority tried to learn the indigenous practice very well, they could use the temple bell instead of passing the message each household in the time of emergency. This incident highlighted how to learn the indigenous practice

to inform and give awareness to the people effectively. This is one of the best examples that we can point out the collaboration of indigenous adaption and the new technology can develop the highly sustainable and effective solution to the community.

#### 3.5.1.3 Practicing "*Attam kramaya*" ( Farming together )

This is derived from the traditional practices. Their main living depends upon cultivation of paddy and vegetables. As they always practice farming by gathering and working together, they can transfer their practices as the tacit knowledge. They always use this method effectively from one generation to another since many years ago. Therefore, the knowledge based on disaster prevention can transfer through this practice.

practice is derived from the ancestors when they went out for hunting and killing animals. They survived in a team and hunt together as a group. Therefore, the practices of hunting and survival passed to one generation to the next in order to improve the knowledge and awareness from the elders. In this study, the practice of Attam Kramaya was derived from this concept. Moreover, this concept helps to transfer the knowledge to the younger generation. However, the younger generation have no awareness and respect over this concept.

In Figure 4.4, the younger generation group showed no valuation and awareness over this practice. The age between 14 to 19 and 20 to 39 groups represents that they have no or less awareness over this concept. However, the age between 40 to 59 and more than 60 groups have very high awareness and valuation over this practice. The very young generation does not have the intention to engage with the farming activity. The elder generations are still practicing this approach.

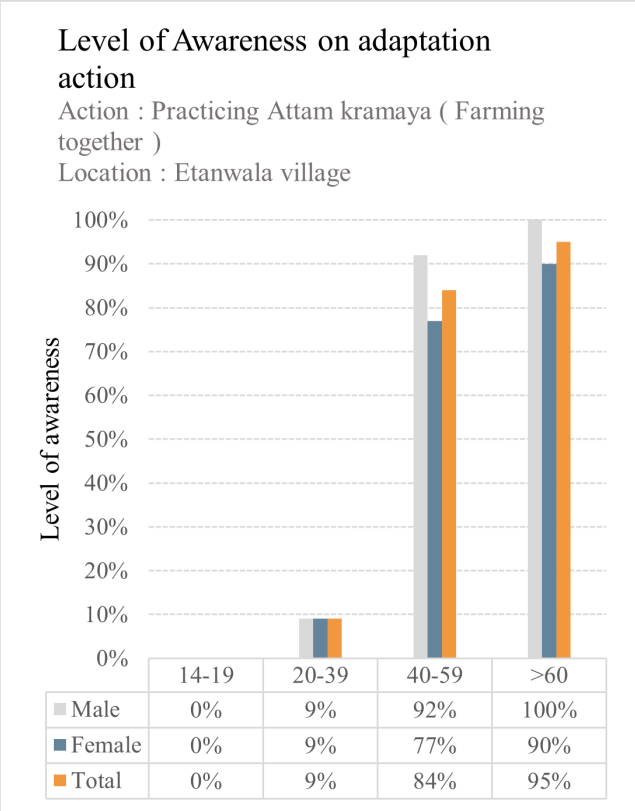



Figure 3.7: Emergency warning based on Temple bell, (N = 80)

Figure 3.8: Farmers harvesting paddy in in Sri Lanka,Source: Daily News Sri Lanka national newspaper 1918 (06-01-2011).

#### 3.5.1.4 Specific Land Use Pattern

The respondents emphasize the importance of land use patterns that reduce the risk of landslides. For the prevention of landslide risks, forest preservation is one of the techniques that can be implemented. To prevent a landslide, villagers preserve the forest in the upper region. They specifically cultivate and protect the tree belts near their home on the upper side against rock falls.

According to the previous land use plan, a distinct pattern of land use can be recognized. Along the valley, the villagers are bordered by a river. On average, one or two flood occurrences can be observed within a year. The people do not build their homes close to the river. All the residences are arranged as a belt around the flood plain. The land between the residential zone and the river is the agricultural region. The community of this village has identified two distinct categories of landslide threats. The first is a rock fall, whereas the second is a debris flow.

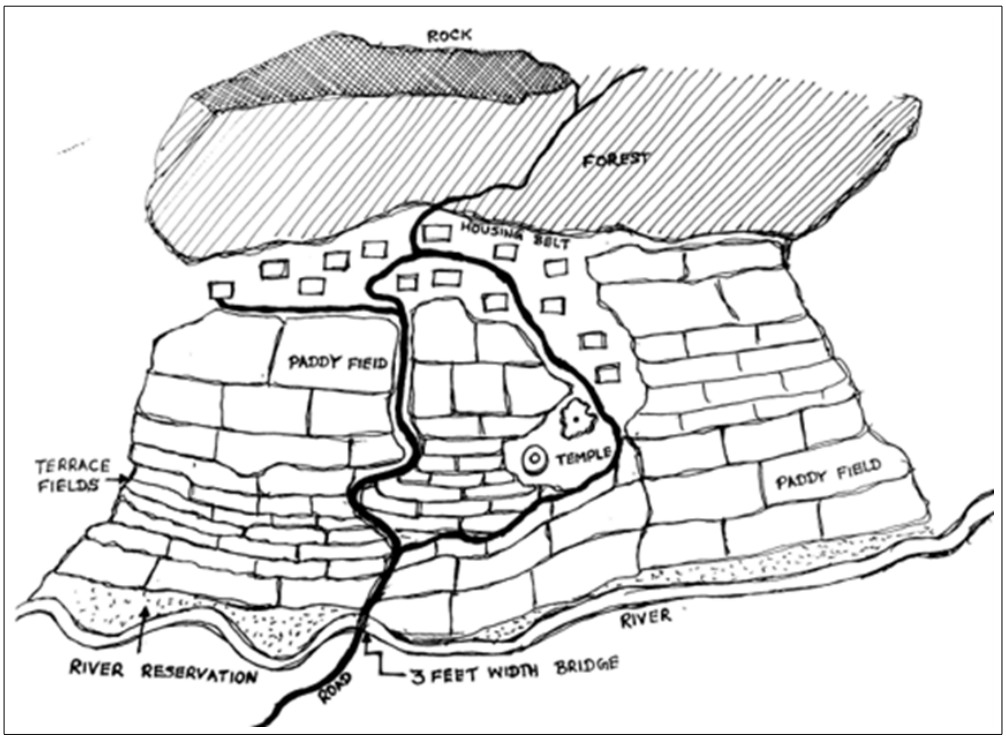



Figure 3.9: Etanwala village layout integrating the forest, the temple, the terrace fields, and homestead. Conceptual. Source: Author.

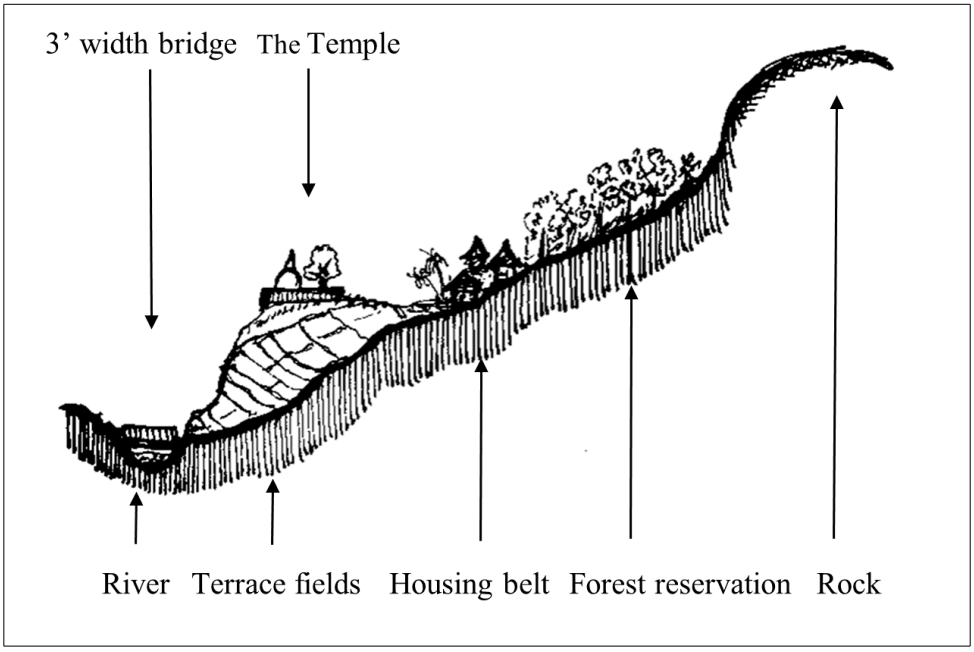



Figure 3.10: Farmers Etanwala village profile, cross section of the village profile (Section A-A in Figure 3.9) Source: Author

Dense vegetation constantly prevents the occurrence of such landslides. The forest is therefore protected from deforestation. If someone attempts to build a home on the land, they must abide by the village's general regulations. One regulation is to plant a three-foot tree belt on the up slope side of the house to prevent rock from falling.

To prevent deforestation, they erected their houses in a consistent way within the belt. During the survey, it was determined that terrace cultivation is the most effective technique for preventing landslide hazards. In order to prevent landslides, as depicted in Figure 4.6, the villagers continue to preserve the forests on the top slope and cultivate the paddy fields in a terrace pattern on the lower slope.

#### 3.5.1.5 Life Fencing and Stone Walls

There is a clear connection between botany and landslide prevention in terms of preventing landslides. One of the methods is to plant trees on sloping terrain, since this would delay the flow of water and the soil-binding roots will prevent soil erosion.

Improving the soil strength and reducing soil erosion and also preventing landslide

Figure 3.11: Pawatta plant used for making live fences and Retaining Walls ,Source: Author

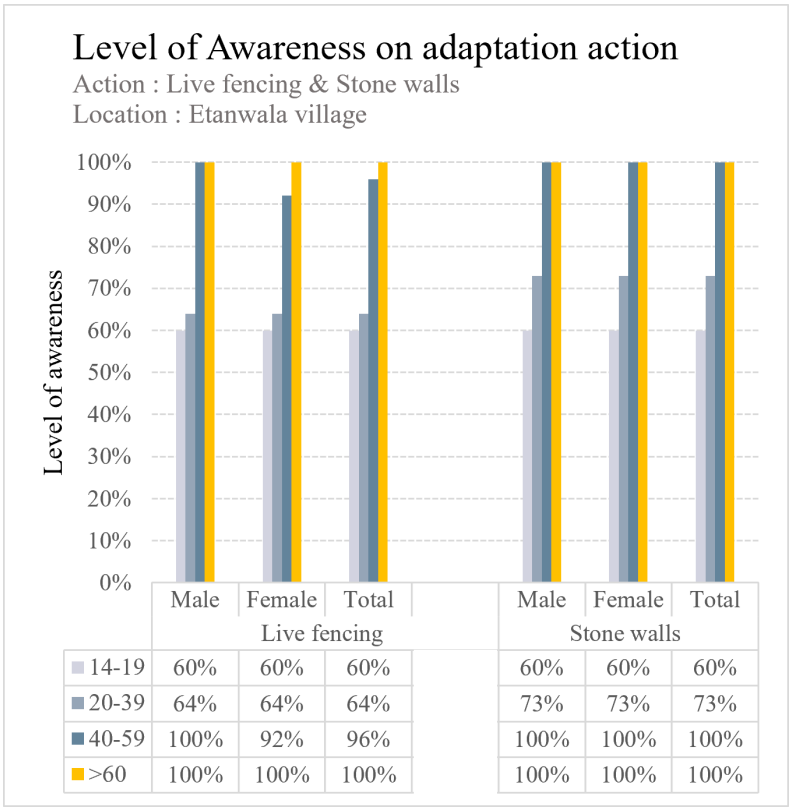



Figure 3.12: Level of awareness on live fencing and stone walls , Source: Author, (N = 80)

failure due to slope cutting, they use two types of techniques, life fencing and stone walls. For the life fencing, they use specific type of medicinal plant called Pawatta , Justicia adhatoda. It not only reduces landslide risks but also provides the indirect medicinal benefits.

For the stone walls, they use their own techniques and use cost effective local materials. Those two methods have their own benefits and are easy to apply in local community.

## 3.5.2 Unique Techniques of the Housing Design

### 3.5.2.1 Evolution of the housing method

According to the historical records, there were four types of housing methods that the villagers used. They are 'Warichchi' House, 'Hataraendi' House, Stone House, and Brick House. At the very beginning of the history, they use 'Warichchi' House. When the population grew up, they use 'Hataraendi' House. It is a special and unique housing design. They used this method for long period of time because the number of villagers in the village was not very high at that time. Therefore, they tried to live together as a one family. These types of house can accommodate three or four houses at once. They built five 'Hataraendi' Houses and lived together inside. After long time, the population increased, and some families tired to move out and lived separately. Hence, they used stone and clay to build Stone Houses. In recent years, the village was developed, and the villagers tried to build the houses with bricks. Nowadays, the four types of housing can be seen in the village including one 'Hataraendi' Housing.

### 3.5.2.2 Hataraendi geya ( Four side house)

Special housing technique can be identified in this village. Mainly the houses consist of four sides (In Sinhala call as 'Hatharadi geya') and the centre having the opening. There are four bedrooms, three store rooms and a kitchen in this particular type of house design. Normally, one to three families are living in these types of houses. In ancient villages, the people normally believe about devil because of their norms and believes. Therefore, living two or three families together made

them feel secure when one or two males went out for protecting their farm lands at night. Also, having this type of fear on devil makes them to construct their houses in a close cluster and made indirectly into particular land use pattern make. Mainly, they used strong timber pillars (Figure 3.13) and clay or termite clay as the main construction materials. Therefore, the life of these houses lasted more than 200 years. There was one part of the traditional house that still remains safe within the village.

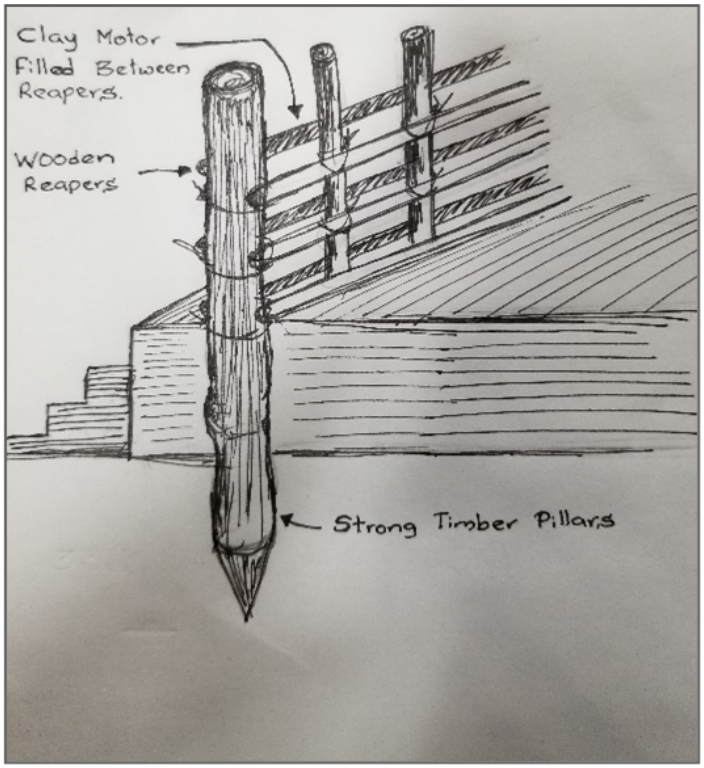



Figure 3.13: Strong timber reinforcement in walls Source: Author

The plan view of the house explained in the above is shown in figure below. Mainly, there are three types of room. One type indicates the bedroom, two are for store rooms and the last one, the kitchen. At the middle of the house, there is an opening for the proper ventilation and sunlight. The plinth level of the house is 2.5 feet above the ground. It prevents from the flooding and the entry of animals. For the structure of the roof, they used strong timber from the forest and applied Mana leaves as the roof cover(Figure 3.14). They prepared at least one feet thick roof cover to prevent from the rain keeping the room cold and comfortable from the

high temperature. The following figure show the plan view of the house design. There is one part of the traditional house remained intact in the village as shown in figure 3.14.


Figure 3.14: 1.'Mana' leaves used as roof cover / 2.Traditional house remained intact in the village and 3.Isometric view of the Traditional house , Source: Author

Especially, they used the clay, stone and timber to construct the house. Strong tree trunks were used as the pillars at each edge. All pillars were braced with wooden reapers across them and filled with clay motor forming the wall.Finally, they used termite clay paste to cover the whole wall as the plastering in order to prevent from the seepage of water and holes. The thickness of the wall is one and half feet and tapered in the upper part of the wall around one half of the lower part. These features of the house make the house resisting the external impacts of environmental changes. Usually, village experts explained that the life span of the house is over 200 years long.

#### 3.5.2.3 Stone wall houses

Construction of homes is one of person's most essential tasks. It modifies and adapts the environment to meet his needs, providing him and his family with protection from the elements, animals, and other people, as well as a secure location in which to live and work. Regardless of the motive for building a house (relocating to a new location, rebuilding in lieu of a destroyed structure, or expanding an existing home), the process had to be same. The necessity and the choice to begin construction came first. Then, a place would be selected, a plan would be

developed, and materials would be gathered. The third phase would consist of the building itself, including creating the foundations, erecting the walls and roof, plastering, installing doors and home appliances, and moving in.

Figure 3.15: Stone wall house , Source: Author

For the stone wall types of houses, they only use the stone as the building material for wall and foundation. For the roofing material, they used dry coconut leaves in the beginning. They also used clay tiles. Later, they used galvanized steel sheet for roofing. The fine clay substance used as mortar for bonding stones together and for plastering.

#### 3.5.2.4 Brick wall houses

After using the stone houses, they changed to use the clay bricks with clay motor. As the society became exposed to the modernized community, they started to use this technique. Instead of using the cement which is expensive and difficult to obtain in this environment, they use the clay motor made by good quality type of clay within the village. Fig show the structure of the clay bricks houses.

Figure 3.16: Brick wall house , Source: Author

### 3.5.3 Significant facts in house construction for landslide risk reduction

Especially, when they are constructing their houses, they consider measurement. Those measurements indirectly gave some safety specifications. In ancient villages, they do not use modern type of measurements and units. Basically, they use very easy and simple dimensions which can be easily understandable for each person in the community. As an example, when they construct a house with a slope cutting, they have the special rule of keeping the rear space of the house. There are mainly two different rules in keeping the rear space. One type is for shallow slope cutting. In shallow slope cutting, they must keep the space enough to pass one pair of the bulls. For deep slope cutting, they must keep the space enough for one pair of elephants. These two rules help to protect them from the slope failure in indirect way.

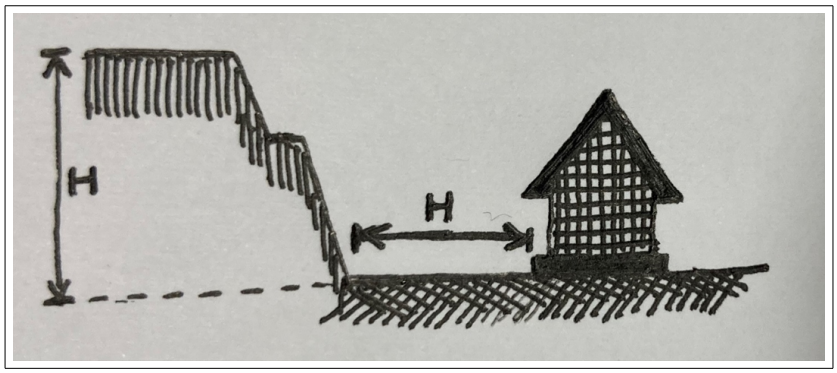



Figure 3.17: Standard regulations for rear space , Source: Author

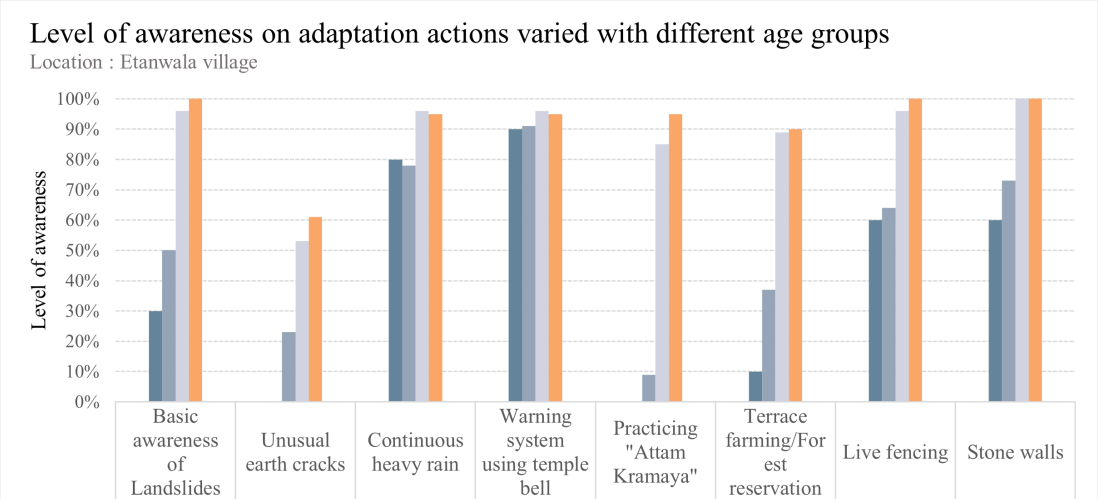
The following are the standard regulations for rear space in slope cutting which are published by the Building Research Organization, Sri Lanka at 2006. They must keep the distance (d) equal to the height (H) of the cut slope for free standing cut slopes as shown in the following figure. The practices that the villagers follow in cutting slopes are almost similar to those published standard regulations. As an example, for 5 to 7 feet high slope cutting, villagers need to keep one pair of bull space that equals to 5- or 6-feet width. For over 10 to 15 feet high slope cutting, they prepare to keep the slope for one pair of elephants which is approximately similar to 12 feet in width. Hence, these two practices are almost similar to the

standard regulations. The villagers remain continued using these practices when they are building the houses. There is also one effective practice in village. During the heavy rainfall, all the family members used to stay in the front part of the house in case for the incidents like slope failure. Reserving the forest in the upper part of the house is also another good practice as in the pattern of three feet width tree belts. It also protects from the rock falling from the uphill side. These are the disaster reduction factors that can be highlighted in the housing technique.

## 3.5.4 Level of awareness on adaptation actions

### 3.5.4.1 Case study - Etanwala village

From this survey, the eight actions are categorized and identified clearly for reducing the landslide risks for this community. These actions can provide advantages for the community and the awareness of these actions vary depending upon the Age groups. The following graph shows the different level of awareness for four Age groups.



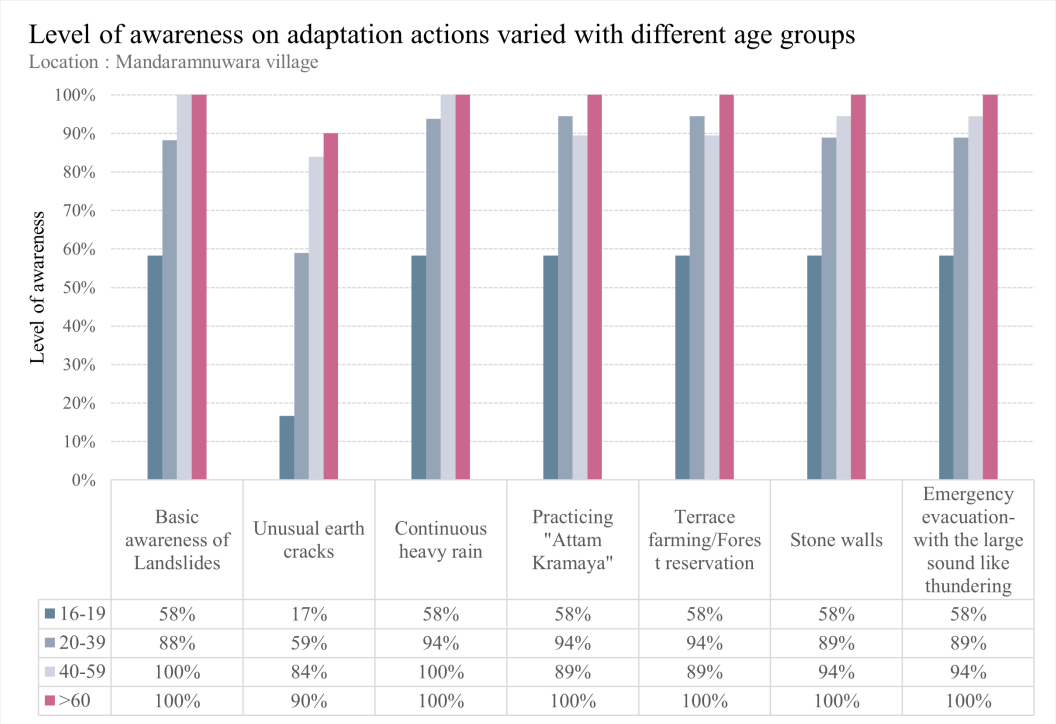

| | Basic awareness of Landslides | Unusual earth cracks | Continuous heavy rain | Warning system using temple bell | Practicing "Attam Kramaya" | Terrace farming/Forest reservation | Live fencing | Stone walls |
|---|---|---|---|---|---|---|---|---|
| 14-19 | 30% | 0% | 80% | 90% | 0% | 10% | 60% | 60% |
| 20-39 | 50% | 23% | 78% | 91% | 9% | 37% | 64% | 73% |
| 40-59 | 96% | 53% | 96% | 96% | 85% | 89% | 96% | 100% |
| >60 | 100% | 61% | 95% | 95% | 95% | 90% | 100% | 100% |

Figure 3.18: Level of awareness on adaptation actions varied with different age groups, Source: Author, (N = 80)

Comparatively low awareness on 'Unusual earth Cracks' in all four age groups with compared to other adaptation actions is shown in the figure 8. High awareness on both 'Continuous heavy rain' and 'Warning system based on temple bell' in all four Age groups with compared to other adaptation actions are described in the above graph. Age group of 12-19 years have very low awareness for all actions other than 'Continuous heavy rain' and 'Warning system based on temple bell'. As overall, the Age group over 40 years have comparatively high awareness on all type of adaptation actions.

### 3.5.4.2 Case study - Mandaramnuwara village

Mandaramnuwara village is administratively named as Mandaramnuwara GN division within the Nuwara Eliya district and more than 80% of the area is susceptible for landslides according to the landslide risk classification which was done by National Building Research Organization Sri Lanka.




| | Basic awareness of Landslides | Unusual earth cracks | Continuous heavy rain | Practicing "Attam Kramaya" | Terrace farming/Forest reservation | Stone walls | Emergency evacuation- with the large sound like thundering |
|---|---|---|---|---|---|---|---|
| 16-19 | 58% | 17% | 58% | 58% | 58% | 58% | 58% |
| 20-39 | 88% | 59% | 94% | 94% | 94% | 89% | 89% |
| 40-59 | 100% | 84% | 100% | 89% | 89% | 94% | 94% |
| >60 | 100% | 90% | 100% | 100% | 100% | 100% | 100% |

Figure 3.19: Level of awareness on adaptation actions varied with different age groups, Source: Author, (N = 60)

Three different field survey methods were undertaken to obtain embedded data

related to local knowledge adaptations. Percentage analysis was used to analyse the data related to different local knowledge adaptation practices and how the level of awareness varies with the different age categories. Finally social network analysis was undertaken to evaluate the Local Knowledge creation and transmission within selected two communities.

Eight local knowledge-based practices/actions related to landslide risk reduction were identified (Figure 3.19). The respondents had known all the local knowledge-based practices by their own experiences. More than four-fifths (93%) of villages are aware of the landslide risk that incurred in their life being in this isolated village. Two different observations actions were identified for the landslide risk prediction. Little more than two third (73%) of villages are aware of the unusual earth cracks are one best pre-indicator for landslide. While little more than four-fifths of villages were responded as continuous heavy rain may cause landslides. Early warning system is an essential component in disaster risk reduction. The village itself has a special method of passing emergency massages. It is embedded in their culture and more than four-fifths (88%) of villages are aware of the warning system based on temple bell. Mainly Sand used for retaining soil instead of using live fencing.

## 3.6 Conclusion

This community is living at a geographically isolated village in landslide prone area of Sri Lanka. However, they still enhanced their adaptation level to live without suffering from a major landslides disaster. Their main income is based on agriculture. They accomplish all the necessary sources from their own land [16].

It is well recognized fact that the main cause of landslides in Sri Lanka is due to human induced reasons [141], mainly the poor land use practices. In that context, it is evident from the survey findings that this community is consciously aware of the possible consequences that may arises from poor land utilization. Around 75% of the people in the area aware about the landslide risks and they always use landslide prevention practices when they aim to change the land use such as

life fencing and stonewall for reducing soil failure. Further they adapt a unique land utilization pattern which prevent the probable landslide risks. They maintain the land area into three portions, the upper area as forest reservation, the middle portion high above the flood plain area, as concentrated housings surrounded by tree belts, the lower area as the paddy fields in the terrace pattern having the benefits to prevent severe landslides. In addition, the overall awareness of the possibilities of landslides can be recognized as a tacit knowledge which transfer from one generation to another as a part of their value system.

# Chapter 4

# Local Knowledge Adaptations on landslide Hazard in Depopulated Mountain Communities in Japan

## 4.1 Introduction

### 4.1.1 Landslide risk in Japan

Landslides recently became one of the most threatening natural disasters, especially in mountainous areas in Japan. Around 70% of Japan is a mountainous area, and therefore, the country often poses mudslides, landslides, slope failures, and other sediment disasters following heavy rains and earthquakes [62, 145]. In addition to the natural disturbance, social factors such as depopulation and the increased rate of aging in rural areas lead to additional natural vulnerability. The depopulation of rural regions in Japan started from the late 1950s due to the demographic changes and large scale rural-urban migration in post-war Japan [46, 117]. As the amount of population in rural mountain areas decreases, their inhabitants age rapidly. The rate of the aging population in Japan (people older than 65) became mid-level among developed countries in 1980s. At present, Japan reaches the top among the charts [56, 142]. These social issues continuously increases the natural disaster risk specially in mountain communities. Due to this negative

trend, the Japanese government established various structural and non-structural actions to prevent disaster risks. The research concerned with the landslide and its related impacts has been carried out before 50 years ago. The 'Landslide Prevention Law' was established and enacted in 1958 for the landslide's prevention and mitigation as the first of its kind in the world [145]. This law stands for the foundation to improve the technologies in controlling the landslide risks in Japan. Since then, landslide investigation methods and several mitigation measures have been developed and continuously advanced [62, 145].

### 4.1.2 Landslide risk risk reduction approach

The strategies and approaches to the preparation of disaster prevention, mitigation, and rehabilitation in developed countries by public or non-governmental agencies are unsuccessful to reduce the vulnerability effectively [96, 106]. The proper establishment and implementation of disaster management need a high degree of adaptability to the local situations. Culture, traditions, and customs play a crucial role in the success or failure of disaster management [83]. On the other hand, it is necessary to take into account the cultural context in affected localities and areas. In order to develop a suitable user-friendly package, the area with customs, traditions, local practices, and ethnic compositions should all be considered [40, 67, 83, 104]. In this situation, the gaps between the technical information generated from the specialists and the information received from the local communities in the form of risk-based knowledge resulting from the previous disasters and familiarity with the environment, which can be vital for locally appropriated solutions exist [58]. Local knowledge can be defined as both beliefs, a set of information, mental abilities, and practices, developed from the adaption practiced through generations by personal interactions [26] and locally 'generated through observations of the local environment' [24]. It becomes the foundation of all environmental solutions for problems related to agriculture, the health care sector, food preparation, natural resource management, education, etc [25, 42, 75, 81, 90]. In addition, local knowledge plays an essential role in contributing the basic techniques and strategies by providing early warning systems and weather forecasting

management for disaster risk reduction [42, 75].

### 4.1.3 Local knowledge in disaster risk reduction

In Japan, the significance of indigenous/local knowledge in disaster risk reduction was emphasized by scholars related to different disaster events during past decades. For example, the one story is told and believed to have been handed down by an ancestor who lives in Sanriku region Japan, a tsunami-prone area that saved many lives in the Great East Japan Earthquake in March 2011 [161]. These phenomena describe how local knowledge is vital in disaster risk reduction among communities applying local knowledge to prevent disastrous events. In addition, many researchers have proved local knowledge as a vital factor of community resilience in the process of disaster risk reduction [11–13, 101, 115]. Furthermore, literature has emphasized the function of local knowledge in disaster recovery [91] and the need for context-specific cultural understanding of disaster response [12, 64]. Nevertheless, the importance of local knowledge in disaster management was discussed and documented [68, 124], but the effect of the consensus of the landslide-related local knowledge in a depopulating community still not correctly identified, especially in the population-depleting mountain communities in Japan. Hence, the lack of theoretical research over the critical concepts related to landslide disasters with local knowledge motivated the present research.

## 4.2 Sub-objective

The sub objective of this section is to observes local knowledge in landslide disaster adaptations and investigates whether a shared, local vision of community sustainability and consensus about risk priorities can be identified.

## 4.3 Study area

This study engages the case study method [154] to investigate how the community members identify and take action to risks and how different adaptation decisions

are made. This method is suitable to explain complicated problems where research and data are abundant, but the diverse situations is challenging to explain with standalone quantitative analysis.

### 4.3.1 Selection of Case study

The study was conducted in and with the community of the one mountain village named Matsunoyama, located in Tokamachi City, in Niigata Prefecture. Matsunoyama was an independent municipality until 2005, then merged into Tokamachi City and another two towns, Kawanishi, Matsudai, including Nakasato village [2]. The area is known for Tanada/Terrace farming, especially in Niigata Prefecture. Tanada act as the primary landscape attracting tourism, including hot bath 'onsen' [1]. Matsunoyama experienced a 46.4% aging rate from 1975 until 2010, and the population decreased by more than half with 5,930 people in 1975 compared with the 2010 population with 2,542 people [4]. Therefore, decreasing population and a high aging rate can be observed as one of the main challenges Matsunoyama communities face today. Nevertheless, the area comes under the risk zone of landslide disasters and makes the community more vulnerable to natural disasters, especially landslides. For example, in April 1962, cracks appeared in Usagiguchi, and two years after that, a full extension of 3,600 meters, an average of 900 meters widths, and a total of around 850 hectares of land of the foot of Matsuyama mountain slipped and moved int northeastern direction toward Koido River. The slip consisted of 7 landslides surrounding Matsunoyama (Figure 4.1). As a result, casualties were 349.9 hectares of paddy field, 371 houses, four schools, 15 public facilities, 98 buildings, 5.4 km of prefectural road, and 14.8 km of town road [111]. Matsunoyama, primarily surrounded by young mountain ranges, possesses steep slopes with unstable geology and a harsh climate to predict. Some areas are incredibly prone to landslides as a result of the meteorological, geographical, and geological conditions and socio-economic characteristics. Therefore, this study selected three communities residing in the Matsunoyama villages with a long history of landslides, located in the shūraku division. Mizunashi Settlement, Shimo Kawate Settlement (Combination of Matsuguchi and Mioke areas), and

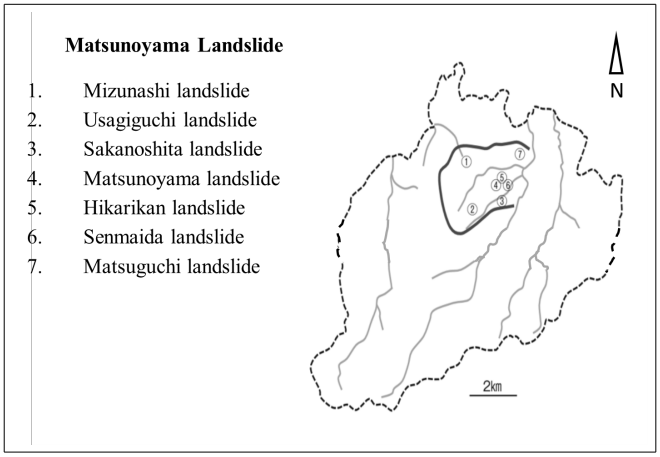



Figure 4.1: Matsunoyama landslide in 1964

Fujikura Settlement were selected for this study based on the advice from the Officials in the Tokamachi city office (Figure 4.2).

Mizunashi is the largest with 4.07 km2, and Shimokawate and Fujikura are 1.40 km2 and 0.70 km2, in area respectively. Depopulation and aging is the primary challenge that these communities are facing. Approximately all three communities had less than 20% elders in 1975, but in 2020 the elderly population reached almost 50% in all communities (Table 4.1). Moreover, The total population is 226,222, and 128 in three divisions Mizunashi, Shimo Kawate, and Fujikura, respectively, in 1975. However, the numbers drastically reduced, and in 2020 the population reached 48, 60, and 30, respectively. Therefore, approximately four-fifths of the total population was depleted in all divisions, with only elders existing in the community (Table 4.1). The irregularity of the population and the risk of landslide disasters are challenging for these mountain dwellers' sustainable future.

Table 4.1: Key demographic characteristics of three study communities

| Shūraku | Land area(km2) | Year - 1975 | | | Year - 2020 | | |
|---|---|---|---|---|---|---|---|
| | | Population | Age > 65 | % | Population | Age > 65 | % |
| Mizunashi | 4.07 | 226 | 28 | 12.39% | 48 | 25 | 52.08% |
| Shimokawate | 1.40 | 222 | 37 | 16.67% | 60 | 31 | 51.67% |
| Fujikura | 0.70 | 128 | 18 | 14.06% | 30 | 14 | 46.67% |

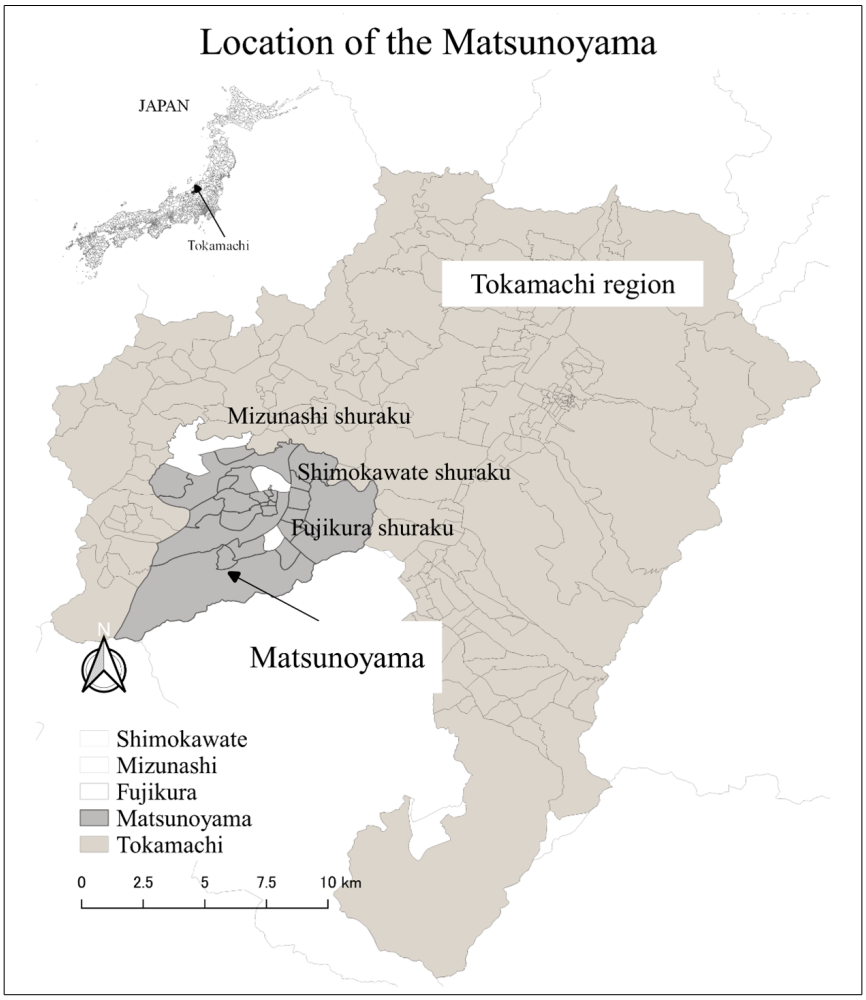



Figure 4.2: Location map of the selected three Shuraku divisions ( Mizunashi, Shimo Kawate and Fujikura ).

## 4.4 Data Collection and Analytical Methods

To gather data on local knowledge on landslide disasters, interviews of the key informants, group discussions, and household surveys were performed in all three village communities. The key informant interviews were done after initial community entry meetings. Based on the data obtained from the preliminary visit and the interviews, a household questionnaire was developed to understand the commonly shared set of local knowledge in landslide disaster risk reduction (Figure 4.5).

The number of field visits was made in this study. A preliminary field visit was completed during June and July 2020. The main purpose was to get familiar with the field area and meet with relevant government officials and village leaders (Figure 4.3). The first field survey was completed from 25th August to 27th August 2020. During the visit, key informant interviews and focus group discussions were done in all three communities. Key informants in this study were made up of the members of traditional knowledge holders recommended by the government officials and the village leaders who met in the preliminary visits. As a second survey, A household questionnaire was developed and distributed on 6th November 2020. Approximately 51% of questionnaire responses were gathered on 23rd November for further analysis.

Figure 4.3: Preliminary field visits and meeting with relevant government officials and village leaders, Source: Author

### 4.4.1 Key Informant Interviews

After initial community entry meetings in communities, key informants were selected using a convenience sampling approach. Key informant interviews were carried out with five informants, and they were 39 years of age or above and have inhabited in the communities for at least 20 years. Key informant interviews were completed using semi-structured questionnaires (Figure 4.4). Discussions were focused on local knowledge-based disaster prediction mechanisms and traditional and local disaster coping strategies. In addition, all interviews were recorded in the local language (Japanese) and later translated into English with the help of a professional translator.

Figure 4.4: Key informant interviews and the group discussions, Source: Author

### 4.4.2 Household Questionnaire surveys

A household questionnaires survey was designed to assess the shared knowledge on landslide disaster awareness and the perceived traditional and local disaster prediction and coping mechanisms. Mainly the question was designed based on the local knowledge components identified through the in-depth interviews. The questionnaires were distributed among all the households in all three divisions30,fe,ff0”80”94twenty in Mizunashi, thirty in Shimokawate, and twelve in Fujikura. However, the research team faced difficulties returning all the distributed survey sheets. The main reason behind this is that the aging population. So many households in those communities remained with very older people; they could not fill questionnaire surveys. However, the research team was finally able to receive a reasonable amount of answer sheets with the help of government officials who

work with these communities. Thirty-two questionnaire sheets were received from all three divisions: eight, sixteen, and eight, respectively.

### 4.4.3 Data Analysis

In Matsunoyama region, people mainly have an agriculture-based life system. However, the location is a high elevation mountain region with a high level of risk for landslide disasters triggered by heavy rainfall and earthquakes. Therefore, the community in the mountainous areas with knowledge on landslide disasters were interviewed, and textual analysis was carried out using interview data. The NVivo 12 was used to identify nodes and categories extracted from the discussions. First, all recorded interview data were converted into memos before starting the analysis process. Next, open coding is used to read the information and identify the statements related to the primary categories. Then, Axial coding was used to identify the categories or the components of the local knowledge related to landslide disasters risk reduction. In addition, the second field survey, the questionnaire survey data, was initially analyzed using descriptive statistics to investigate awareness over different local knowledge components. And finally used as an input for cultural consensus analysis to identify the common and culturally consensus set of local knowledge over landslide disaster adaptation (Figure 4.5).

### 4.4.4 Cultural Consensus Analysis

Cultural consensus theory was established by Romney et al. [120] for researchers to analyze the variation among groups and clarify what they term cultural 'truths' and the extent to which these 'truths' are shared in a statistically significant, able, and replicable manner.The formal consensus model was utilized in this study to investigate the survey results and test for cultural consensus, and ran the tests were in UCINET 6 [65, 90, 118]. As the resulting output, culture-specific answer key for the survey, cultural competency scores for each respondent, and a first- and second-factor eigenvalues ratio were formed.

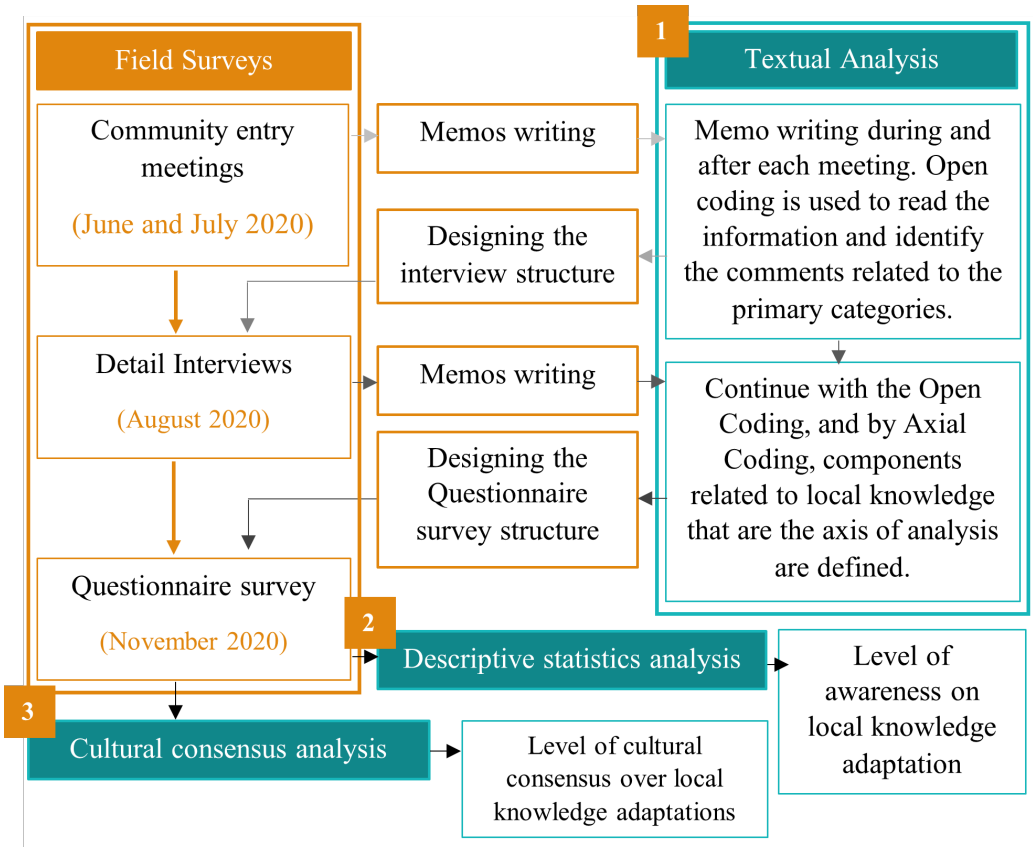



Figure 4.5: Framework of the study

#### 4.4.4.1 Cultural Consensus Analysis Calculation

The mathematical analysis assumes that participants share a cultural model, causing their rankings to be similar [138]. Let C1 equal participant 1's cultural knowledge on landslide disaster risk reduction ,the probability of producing the 'culturally correct' (and unknown to us) answer. Let N equal the number of statements being sorted. Then the probability (P1) that participant 1 ranks the group's most important response first is:

$$P_1 = C_1(knows) + (1 - C_1)/N(guesses) \tag{4.1}$$

Rearranging this equation, the first participant's competence is:

$$C_1 = (NP_1 - 1)/(N - 1) \tag{4.2}$$

The chance that participant 1 and participant 2 both rank a statement first is the sum of them both knowing, C1C2, plus one knowing and two guessing, $C1(1 - C2/N)$, plus one guessing and two knowing, $C2(1 - C1/N)$, plus both guessing $(1 - C1)(1 - C2)/N$, equals:

$$P_{1,2} = C_1C_2 + C_1(1 - C_2/N) + C_2(1 - C_1/N) + (1 - C_1)(1 - C_2)/N \tag{4.3}$$

or

$$P_{1,2} = C_1C_2 + (1 - C_1C_2)/N \tag{4.4}$$

Thus, the agreement between any two participants is a function of the product of their cultural knowledge. On average, the more they agree, the greater their cultural knowledge. Rearranging the above equation:

$$C_1C_2 = (NP_{1,2} - 1)/(N - 1) \tag{4.5}$$

This key relationship, that the product of any two participants' cultural knowledge is a function of their similarities of response corrected for guessing, is then

utilized.

Equation 5 is one equation with two unknowns (C1and C2), and cannot be solved. However, an $S \times S$ matrix (S, number of participants) of matches between participants contains S. $(S1)/2$ point estimates with S unknowns, and can be analyzed by best fit. A least squares factor analysis of this matrix, using the minimum residual method, [37] estimates the cultural knowledge (C) for each participant. If the assumption of shared cultural knowledge is true, then it should explain the greatest amount of variance in the data. The standard assumption is an eigenvalue ratio of 3 : 1 between the first (cultural knowledge) and second (any other) factor. This acts as a check on the assumptions of the model.

If shared culture is established by this criterion, the a priori estimates of C, and the actual rankings by each individual, are then used to determine a posteriori the 'culturally correct' answers for each cultural group.5 These rankings are then compared between groups, looking for important discrepancies.

## 4.5 Empirical Findings

### 4.5.1 Components of the Local knowledge adaptation for the Landslide Disasters

Initially, several components of the local knowledge on landslides were identified based on the in-depth interview answers by running textual analysis. As a result, five components related to local knowledge were extracted (Figure 4.6). The term landslide was deeply embedded into their culture means that the community is aware of the risk involved in landslides. Therefore the community defines the landslide using their terms. The word 'Kura' in the local terms is used for small earth slips, and the name 'Noge' and 'Nuge' are used if the size of the earth slips larger and cannot be corrected by one person. Large landslide called as 'Oonoge'. Therefore these communities use ***different terms for landslides in their local language***.

Moreover, the community members in the village know where landslides are possible. According to their knowledge, usually, landslides occur in rice fields and

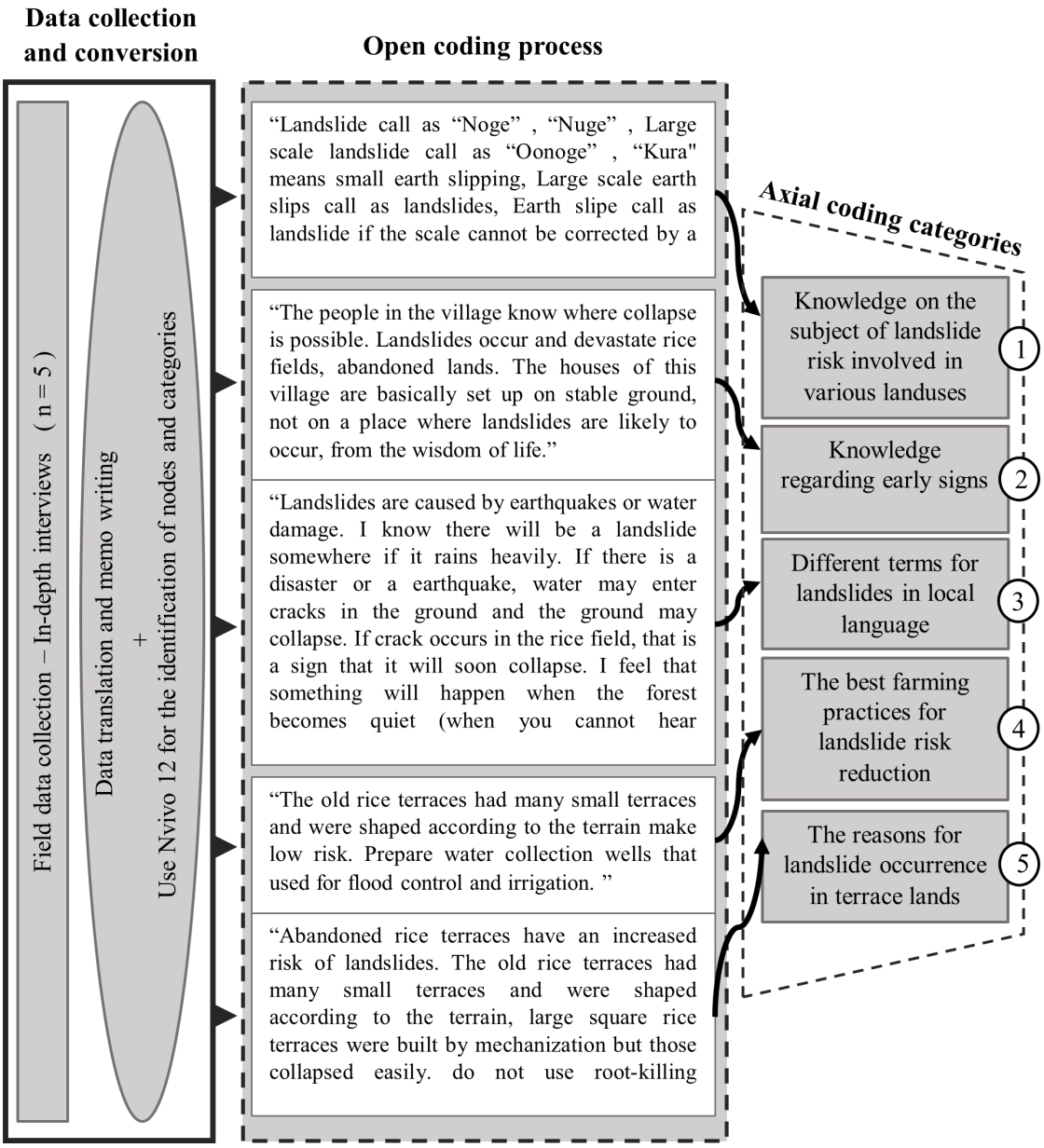



Figure 4.6: Summary of the local knowledge components extraction process using Text coding

abandoned lands. Their village houses are set up on stable ground, not in a place where landslides are likely to occur, from the wisdom of life. Therefore they received proper knowledge of landslide risk areas from their elders and learned by themselves by living in this landslide risk environment. This means they have deep ***knowledge about landslide risks involved in various landuses***. The communities discovered distinct environmental phenomena for use as early indicators for the potential disasters in their living environment. For example, since the three communities in this study had the risk of landslides, they identified different early signs for landslides, such as cracks on the rice fields, movements of animals different from usual, etc. Therefore these communities have locally developed methods and ***knowledge regarding early signs for landslides***. Rice farming is a part of their life and science past Matsunoyama known for Tanada/Terrace farming, especially in Niigata Prefecture. Most of the terrace lands were abandoned with the depopulation crisis.

Nevertheless, Still, the area consists of a reasonable amount of rice fields. Mizunashi consists of 0.15 km2, and Shimokawate and Fujikura are 0.17 km2 and 0.06 km2. While engaged in farming in the landslide risk environment, they develop best practices to reduce landslide risk in farmlands. Developing the farmlands without changing the natural shapes of the mountain and the additional water removal wells are some of their practice methods. This makes it evident that these communities are well aware of ***the best farming practices for landslide risk reduction***.Moreover, the community respects their own techniques for farming, but some individuals try to adopt new technologies to improve productivity. This makes positive insights for the production while some techniques increase the risk for landslides. The use of root-killing herbicides and the reshaping of the terrace steps are the few reasons that they highlighted as ***the reasons for landslide occurrence in terrace lands***.

### 4.5.2 Level of awareness on adaptation actions

The questionnaire survey was designed based on the above key knowledge components and the data acquired during the field observations. The data was initially

analyzed using descriptive statistical methods to check the level of awareness of the individuals within the communities. Approximately 80% of the participants had more than 40% awareness of local knowledge on landslide disasters. Five individuals have a level of awareness over 75%. They were in age between 50 to 75 years and resided in the area for more than 40 years. They all have good experiences with farming. The good experience in farming and spending a long period in this area made them well aware of the surrounding environment and respond to the stress from natural disasters like landslides. Out of five, one is female (Figure 4.7).

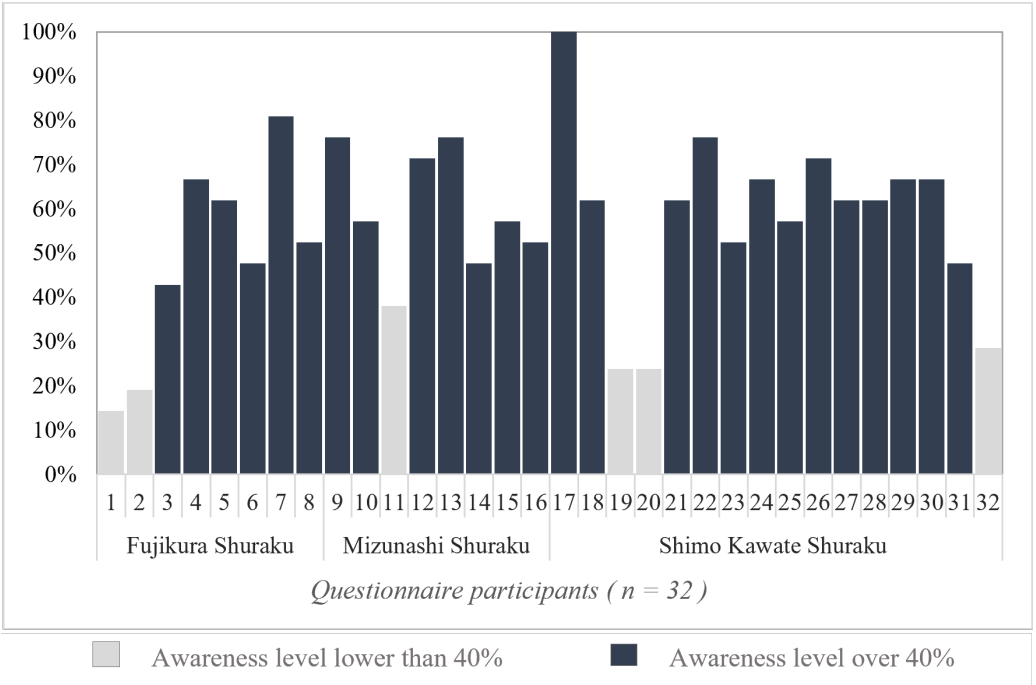



Figure 4.7: Level of awareness on local knowledge relate with landslides

Moreover, the six individuals had awareness lower than 40%. Three of them were over 80 years old females, making it difficult to respond to questionnaires. The other three resided in the area for less than 20 years and have no experience in farming. In summary, the individuals who have more experience farming in the area for an extended period have more knowledge of landslide disaster risk and best practices to reduce the risk.

### 4.5.3 Consensus of Local knowledge of landslide disasters

To investigate the survey results and test for cultural consensus, the formal consensus model was utilized, and ran the tests were in UCINET 6 [86, 118, 122]. As the resulting output, culture-specific answer key for the survey, cultural competency scores for each respondent, and a first- and second-factor eigenvalues ratio were formed. Respondent answers are weighted based on the respondent's relative cultural competency score to produce the culture-specific answer key. It indicates that the respondents who agree with the majority are weighted more strongly, allowing for a more representative and correct answer key that cultural outsiders do not skew. However, if the ratio of first- and second-factor eigenvalues is greater than three, this answer key can be accepted [65]. The results show the consensus level over three, which means that the condition is met. Furthermore, all participants as a group indicated a shared cultural model: eigenvalue ratio=4.33 (Figure 4.8), mean cultural competency score of the sample=0.60, SD=0.15, and no negative factor loadings. Therefore results can be concluded that respondents draw from a single, shared knowledge set.

| | |
|---|---|
| Consensus level | 4.33 |
| Largest eigenvalue | 12.33 |
| Second largest eigenvalue | 2.85 |
| Number of negative loading scores | 0 |

Table 4.2: Summary of the Cultural consensus analysis results

According to our cultural consensus analysis (eigenvalue ratio, competence scores), the results show that there does occur an established cultural consensus model indicating culturally framed local knowledge concerning landslide disasters. The cultural consensus model encompasses the techniques and practices used by the participants to reduce the landslide risk in their livelihood. Furthermore, most participants were aware of the different types of land uses, increasing landslide risks. For example, 61.56% and 62.44% of respondents agreed that the paddy fields and abandoned lands could impose higher landslide risks while residential, terrace, and forest lands have a low risk of sliding (93.19%,1.94%, and 82.03%).

| Statement | Consensus results | The weighted proportion of respondents who agree with the consensus result (%) |
|---|---|---|
| ***1. Knowledge on the subject of landslide risk involved in various landuses*** | | |
| *A. Types of land use which can increase the landslide risks* | | |
| A1. Residential land | Disagree | 93.19 |
| A2. Paddy fields | Agree | 61.56 |
| A3. Terrace lands | Disagree | 91.94 |
| A4. Abandoned lands | Agree | 62.44 |
| A5. Forests | Disagree | 82.03 |
| *B. Best landuse type for landslide occurred land* | | |
| B1. Residential land | Disagree | 100 |
| B2. Paddy fields | Agree | 57.03 |
| B3. Terrace lands | Disagree | 100 |
| B4. Abandoned lands | Agree | 77.59 |
| B5. Landslide prevention work | Agree | 57.78 |
| ***2. Knowledge regarding early signs for landslides*** | | |
| *C. Triggers for the landslide disaster* | | |
| C1. Continuous rain | Agree | 74.44 |
| C2. Earthquake occurrence | Agree | 75.16 |
| *D. Early signs for landslides* | | |
| D1. Cracks in the ground | Agree | 69.53 |
| D2. Tree tilts downwards | Disagree | 65.03 |
| D3. Sounds comes from the tree roots | Disagree | 53.03 |
| D4. Muddy water spring | Agree | 58.78 |
| D5. Movements of animals different from usual | Disagree | 94.34 |
| ***3. Different terms for landslides in local language*** | | |
| *E. Local term for landslides* | | |
| E1. "Noge" | Agree | 66.22 |
| E2. "Nuge" | Disagree | 65.72 |
| ***4. The best farming practices for landslide risk reduction*** | | |
| *F. Best farming practices for landslide risk reduction* | | |
| F1. Building farmlands without changing the shape of the mountain, Keep the shape of each terrace field small | Agree | 63.19 |
| F2. Prepare the fields to be large size to make easier for machinery use. | Agree | 55.91 |
| F3. Built access water removal wells | Disagree | 64.12 |
| F4. Prepare proper drainage system | Agree | 68.22 |
| ***5. The reasons for landslide occurrence in terrace lands*** | | |
| *G. Reasons for landslide occurrence in terrace fields* | | |
| G1. Terrace abandonment | Agree | 82.97 |
| G2. Increasing the size of the terrace steps | Disagree | 69.59 |
| G3. Use of herbicides and other chemicals | Agree | 70.09 |

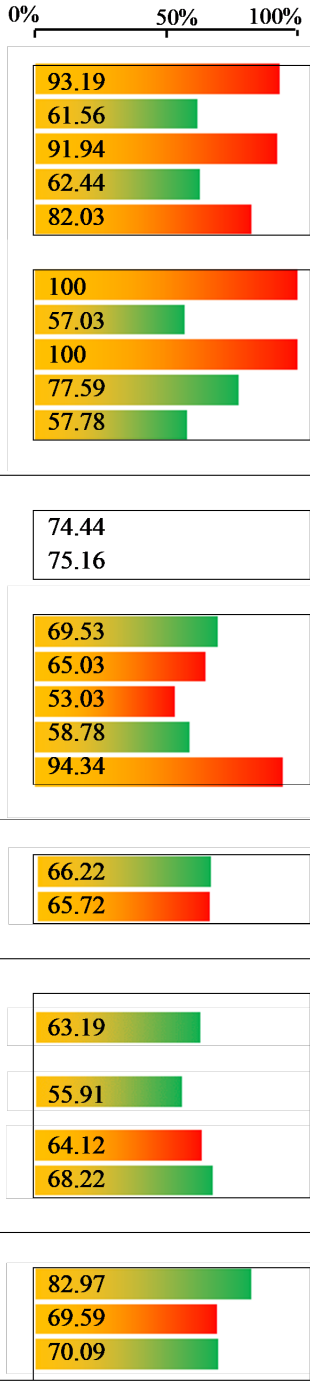



Figure 4.8: Cultural consensus analysis responses regarding local knowledge on landslides

Due to the depopulation in the rural communities, the number of farmers decreases. Therefore, most paddy fields are abandoned, and unmaintained paddy fields can create high risks of landslide disaster. However, after the landslide incident, the community identified the risk involved and never used those lands for residential purposes (100%), and 77.59% agreed that they keep those land as abundant. Currently, disaster prediction procedures are valuable and effective with advanced technologies. However, in this approach, the local knowledge concerning the early signs is consistent and valuable for the local community. Four major early signs concerning disaster prediction were identified, which were applied by communities for landslides in this study. The majority of the participants (74.44% and 75.16%) agreed that continuous rainfall and earthquake are the primary triggers for landslides and can be used as early indicators because local inhabitants get cautions for the landslide risks as soon as they notice the heavy continuous rainfall incident for three or four days and the earthquake occurrences (Figure 4.8).

Moreover, unusual earth cracks can be easily detected by checking the recently occurred cracks on the ground; local inhabitants can assume the area has a high potential for landslides. In addition, 58.78% of respondents agreed to use newly appeared muddy water springs as early indicators for landslides (Figure 4.8). As per the interview details, the community used different local terms for landslides like 'Kura, Noge , Nuge, and Oonoge'. However, 66.22% of questionnaire participants were agreed that they usually used 'Noge' to call landslide. The local term for landslide indicates that it is a part of their livelihood and culture. Therefore, the community adopted the condition and the risk created from the living environment. Since most individuals engage in full-time or part-time farming, they adopt various best farming practices to avoid landslide risk. For example, building farmlands without changing the shape of the mountain while keeping the size of each terrace field small is one best practice that they have used ever since their ancestors (agreed 63.19%).

Furthermore, 68.22% of individuals were mentioned that the proper drainage system for the runoff water could reduce the landslide risk of the farmlands. Never-

theless, some farmers are trying to use new machinery in farming. For example, since the larger paddy fields are easy to work with machinery, the farmers try to reshape the terrace fields without considering the landslide risk involved. Therefore 55.91% of individuals emphasize that reshaping the paddy lands is the best practice by considering productivity. However, depopulation and aging negatively impact the traditional way of farming. Lack of workers and the existing farmers get old and make them use comfortable methods for farming rather than considering risk factors. In addition, depopulation increases the number of abundant farmlands within the area. Therefore, 82.97% of the participants mentioned that the abundant farmlands course for the landslides occurrences in terrace fields. Other than the above reason, using herbicides and other chemicals can destroy all the grass , plants, and root systems, make the soil loosened, and create earth slides (agreed 70.09%).

## 4.6 Discussion

### 4.6.1 The consensus of local knowledge on landslide disasters in Mountain communities in Japan

All three communities in this study live in a mountain village in the landslide-prone area of Japan. Nevertheless, they still improved their adaptation to surviving without experiencing a significant landslides disaster. Local knowledge created on disaster experiences must be individually attained and explained by individuals and the community. The community members should understand to lessen their contact with the threats, which would be a direct and efficient approach to decrease disaster hazards and minimize landslides' impact [75]. The interview results emphasized that the people living in these mountain villages have proper and well-developed local knowledge over landslide disaster adaptation. The area is primarily agricultural livelihood, and a reasonable amount of land was used for rice farming from the historic period. The individuals who engage in agriculture and have lived in this mountain community for an extended period acquire a sufficient amount of experience. The experience or the exposure to the stress

from the natural environment like disasters make them develop their methods to living without disaster risk. However, the level of awareness varied with the level of experience and the exposure; the individuals who lived extended periods while engaged in farming have a high level of awareness over local knowledge on landslides, while individuals who live shorter periods and who did not engage in the farming show a low level of awareness.

Nevertheless, on average, all the community was well aware of the basics of the exposed disasters and the risk involved. In that context, it is evident from the survey findings that this community has a consensus of the local knowledge on landslide disasters. Once consensus is reached, using local knowledge to address landslide disaster risk prevention might guarantee that the risk prevention measures achieved the community needs [94]. All the community members have a consensus over different practices and believe in landslide disaster risk reduction. Further, they adopt unique practices and methods which prevent the probable landslide risks within their communities. The risk involved in different landuses, early indicators for landslide prediction, and best farming practices are the main critical aspects in which they are confident. Therefore, the consensus of the local knowledge on landslide disasters is the one main factor facilitating the sustainable future of these mountain communities.

### 4.6.2 Impact of the depopulation and aging over the sustainability of the mountain community in a landslide disaster environment

#### 4.6.2.1 Depopulation and aging issue of the mountain communities in Japan

The scenario of the ongoing rural depopulation of mountain villages in Japan is critical. Approximately 70% of the population depleted from 1975 to 2020 in all three communities, while the remaining population consists of over 50% elders. As a result, most young generations tend to shift from their traditional lands to the main cities to engage in numerous jobs other than farming. Moreover,

depopulation and aging have directly affected the livelihood of these mountain communities.

#### 4.6.2.2 The influence of depopulation and aging on the long-term viability of the mountain village in the context of a landslide disaster

The research findings show that the one main issue is terrace abandonment, and the effect of terrace abandonment is the occurrence of degradation processes such as erosion [63, 123, 130]. This subsequently leads to an increase in landslide risks [**?**, 7]. The community and some researchers found the critical condition facing these mountain communities; the issue remains the same and shows the condition moving to the worse in the future [**?**]. This trend will direct a more vulnerable environment for livelihood with the effect of natural disasters like landslides. However, the lack of workers and the aging make the community shift to the new machinery use while abandoning the traditional way of farming. Using machinery, they try to reshape the terrace lands with larger steps. Even though the farmers know from their own experiences the consequences like landslides risk can be increased, they ended up with no other alternative to continue their livelihood. In summary, terrace abandonment and the reshaping of terrace lands happen because of the population depletion in these mountain communities. At present, the study three communities in a critical socio-economic condition with the potential risk from the living environment attached with landslide disasters; however, the consensus of the local knowledge on landslide disaster adaptations makes the condition controlled to some extent. Nevertheless the negative trend subsequently leads to an increase in landslide risks and affects the sustainable future of these mountain communities.

## 4.7 Conclusion

Even though the mountain communities in Japan are depopulated, and in a critical condition, they adapted well to the landslide disaster environment with a unique

collection of local and traditional knowledge. The study reveals the unique term for landslide “Noge” emphasizes how much the concept of landslide is embedded in their culture from their ancestors. Furthermore, the research findings indicate how the local knowledge-based practices had enhanced the disaster adaptation level of the community. Knowing the landslide risk involved in different landuses is the key to appropriate landuse planning. However the terrace abandonment and the new farming techniques made the farm land risk in landslides, the community well knowledged in best farming practices to reduce landslide risk. In addition, the community believes different phenomena as early indicators for landslide disasters; the continuous heavy rain and the earthquake as immediate indicators, the earth cracks and muddy springs as other indicators that can be used for landslide prediction. Furthermore, the consensuses of the local knowledge showed us how well those best practices and beliefs are shared among individuals within villages. Therefore, the all three communities have a consensus of local knowledge, and it is essential for achieving safer livelihood as a unit. However, the transfer of local knowledge is directly affected by depopulation in these mountain communities, which can be leads to the disappearance of valuable local knowledge in the future. In a summary local knowledge and consensuses are key strengths of these communities to adapt to landslide disasters environment. Therefore, the authorities should understand the value of the local knowledge for the sustainability of these mountain communities. Although modern scientific knowledge for disaster risk reduction is vital, it is essential to recognize the role of traditional and local knowledge in enhancing the resilience of local communities, especially in the context of depopulating mountain communities. The research findings initially highlighted the value of local knowledge in the disaster risk reduction process. Moreover, the findings can act as a key foundation for building a hybrid approach containing local knowledge and scientific knowledge to cope with the risks associated with landslide disasters.

# Chapter 5

# Local Knowledge evolution and transfer in a network of rural communities

## 5.1 Introduction

Knowledge transfer is a branch of knowledge management, focusing on the movement of knowledge across boundaries, which are created by specialized knowledge domains, by transferring knowledge from one place, person, or ownership to another [34]. Therefore, successful knowledge transfer results in receiving, accumulating, or assimilating new knowledge [92]. Knowledge sharing is a people-to-people process. Holden and von Kortzfleisch [76] explained the theory of translation. It includes knowledge transfer as a networking activity. Networks provide individuals with access to knowledge, resources, or technologies. Through membership in a network and the resulting repeated and long-term knowledge exchange relationships, the network members create the potential for knowledge acquisition [17, 91, 92, 144]. Recently, access to new sources of knowledge is one of the most important direct benefits of social capital [144]. Moreover, evidence suggests that knowledge transfer is facilitated by intensive social interactions of organizational actors [159].

Four decades ago, Granovetter [69] postulated social capital as a collective re-

source to attain knowledge flow through weak bridging ties. Since then, scholarly work linking social capital with knowledge transfer has received the attention of social researchers. Research on linking social capital and knowledge transfer had been focused on a few specific areas of interest with several researchers focusing on knowledge transfer in different network types [32, 49, 78, 80]. Nonetheless, the majority of the existing literature is limited to knowledge transfer in a single network type [49,144]. A handful of researchers have validated the trust factor in networks and its impact on knowledge transfer [49,57]; but very few scholars have addressed the impact of social norms on knowledge transfer [105]. Some researchers have focused on the impact of networks on knowledge transfer and innovation [3,62,78]. Accordingly, past research accentuates that social capital plays a significant role in knowledge transfer.

The importance of social capital has been discussed in different disciplines – i.e. social science, economics, environmental management etc. Moreover, different researchers have identified social capital as a critical component of community resilience in the disaster risk reduction process [10, 11, 13, 101, 115]. Literature has focused on the dominance of social networks in disaster recovery [91], the positive and negative influence of social capital in disaster response and the need for context-specific cultural understanding of disaster response [10,64,134]. This is because social capital in disaster management appears to have differential effects for different people, depending on their particular socio-cultural context [11,134,143]. Entoh Tohani [143] investigated the role of social capital in a community that is highly vulnerable to eruption, and the study highlights that social capital covering values and norms, commitment, trust, networking and sharing of information or knowledge provides benefits in the form of increased community awareness of disaster, social solidarity, and disaster knowledge of the villages [143]. Sarita Panday's [28] study, focusing on the strength of social capital in disaster recovery based on the Nepal earthquake in 2015, emphasizes how bonding, bridging and linking social capital can influence the disaster recovery stage. Ananda Y. Karunarathne [82] investigated the evolution of social capital legacies in response to flood disasters in rural and urban areas in Sri Lanka. The findings reveal that

social capital had evolved at different flood inundation phases, and played a vital role in recovering village livelihoods affected in past disaster events. Thus, bonding, bridging, and linking social capital helped reduce the adverse effects of past floods. Yong Lu etl [93] analyzed the information exchange in virtual communities under extreme disaster conditions, and this research has found that structural capital increases information quantity, whereas relational capital and cognitive capital increase information quality. However, some scholars argue that the inclusion of social capital into network analysis and knowledge transfer has not been discussed in the past literature sufficiently [140]; and also there are relatively few studies conducted in rural regions of developing countries [48,74,144]. Furthermore, none of the researchers have focused on the context of a rural community in a landslide disaster risk environment. In the Sri Lankan context, the unavailability of literature is critical, as this limits the opportunity to examine the multilevel view of social capital, and how knowledge is acquired and transferred in different social networks.

The evolution of knowledge and their subsequent transfer is an essential factor in preserving these valuable local knowledge systems. Many studies have been conducted to identify the adoption of local knowledge to address climate change, drought, typhoons, etc. [25]. However, few studies exist on the adoption of local knowledge for landslide disasters [42, 90]. Despite these positive attributes, the possibility of integrating traditional and locally derived mechanisms into formal disaster risk-reduction strategies is low. Therefore, understanding these conventional disaster risk reduction mechanisms and the process of knowledge transfer is critically required [50, 66, 95]. However, few researchers have focused on analyzing the community's social networks, social capital, and disaster-related local knowledge transfer mechanisms in communities that are sustainably adapted to disasters [82,93]. Thus, a theoretical gap in research on the key concepts of social networks, social capital, and local knowledge transfer among network members associated with landslide disasters motivated the present research.

Subsequently, the aim of this research is to examine how the social capital dimensions of networks that affect the ability of a community to acquire local knowledge

of landslide disasters from the network, and facilitate the transfer of knowledge among network members. The remainder of this paper is organized as follows. Literature review includes definitions of terms associated with the study. The research methods have been discussed in the next section. The research findings, which emphasize the role of social capital in local knowledge transfer for landslide disasters are presented in the fourth section. Finally, the conclusion includes discussions of the findings and provides future directives for further research.

## 5.2 Materials and methods

### 5.2.1 Study area

The present study focuses on two communities located in the Matale and Nuwara Eliya districts in the central mountainous region of Sri Lanka. The districts are majorly surrounded by central mountain ranges, which are young, have unstable geology, steep slopes, and climate that is difficult to predict. Due to the meteorological, geographical, and geological conditions, and socio-economic characteristics, some regions are highly susceptible to landslides. Therefore, this study selected two communities residing in the Etanwala and Mandaramnuwara villages, which have a long history of landslides, and are located in the Grama Niladari division.

This study considers various aspects during the selection of case studies. It primarily assumes that the communities have already adapted to landslide disasters. Multiple reasons exist for considering this assumption. First, both communities have a history of landslides, but several generations still reside in the areas and have not changed their geographical locations. Second, spatial and non-spatial local adaptation measures for landslides were identified in both the communities. Therefore, this study assumes that Etanwala and Mandaramnuwara villages are sustainably adapted to landslide disasters.

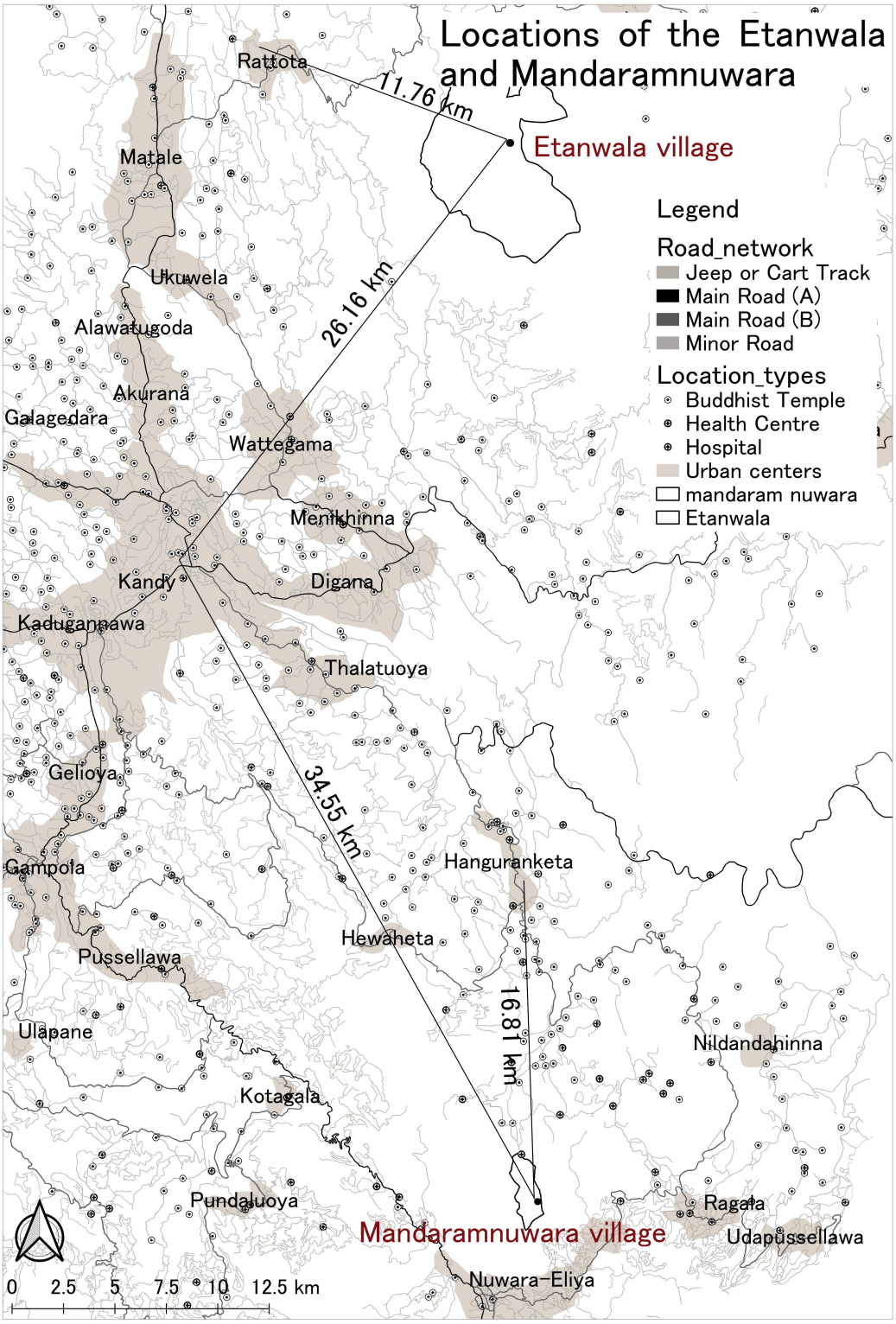



Figure 5.1: Location map showing Etanwala and Mandaramnuwara villages,Source: Survey department of Sri Lanka.

#### 5.2.1.1 Introduction to case study 1 – Etanwala village

Etanwala village is administratively named as the Etanwala Grama Niladari division within the Matale District. The total village land area is 42 km2. The total population of the village is 154 individuals, with 59 families living in 48 houses. The village is approximately 11.76 km at a direct distance and 29.1 km by road from the city center of the nearest town, Rattota. However, its distance from the main city, Kandy, is 26.16 km directly and 64.1 km by road (Figure 5.1). According to the distribution of land uses, more than 50% of the village is surrounded by forests. The community residing in this village is predominantly agricultural, mainly engaged in rice and vegetable cultivation. More than half of the area is cultivated (approximately 84%), approximately 14% of the area is covered with forests, and only 2% is covered with settlements. Kalu Ganga Black River is the primary water source used for cultivation and domestic purposes. The river separates the village from other areas and connects the village by a 3 m bridge. Furthermore, more than 90village area is susceptible to landslides according to the landslide risk classification performed by the National Building Research Organization, Sri Lanka; additionally, two small-scale landslides have occurred in the village. Debris flow and rockfall landslides are the two types of landslides that can be expected in this area.

#### 5.2.1.2 Introduction to case study 2 – Mandaramnuwara village

Mandaramnuwara village in the Nuwara Eliya District was selected as the second case study. It is located 16.81 km at a direct distance and 24.9 km by road from the city center of the nearest town, Hanguranketha. Moreover, it is 34.55 km at a direct distance and 56.7 km by road from Kandy (Figure 5.1). The total village land area is 37 km2. The total population is 323 individuals, with 112 families residing in 89 houses. More than two-thirds of the village area is covered by forests. According to the distribution of land uses, more than 70% of the area is surrounded by forests. Sudu Ganga River is the primary source of water used mainly for domestic purposes and cultivation. According to the landslide risk classification by National Building Research Organization, more than 80% of the

area is susceptible to landslides. Nearly two small and one medium-scale landslides have occurred in the village. Debris flow type of landslides can be expected in this area.

### 5.2.2 Data collection and analytical methods

Interviews of the key informants, group discussions, and household surveys were conducted in both the village communities to collect data on social ties, and evolution and transfer of a constituent of traditional knowledge. Key informants were traditional knowledge holders or village leaders. The initial community meeting was done with the responsible government officers appointed to each village, identified as "Gramaniladari": as in any qualitative study, it is a requirement that the researcher approaches the region and its people. Accordingly, two field visits were conducted in this study; and a preliminary field survey was conducted in early 2018. A household questionnaire was developed, based on the data obtained from the preliminary visit, to understand the network ties in knowledge sharing.

#### 5.2.2.1 Key informant interviews

After the initial community entry meetings in both communities, key informants were selected using a snowball sampling approach. Initially, the discussion was held with the 'Gramaniladari', appointed as a community officer in this village. After explaining the research purpose thoroughly, he was requested to list a few candidates for further interviews. A preliminary interview was conducted with one village elder named by the government officer, during the initial visit. The interview followed the same procedure to approach the second village. A detailed interview series commenced, with the persons listed by the community officer from the two villages. Nevertheless, at the end of each interview, the interviewees suggested the names of another suitable individual to have an interview with. Finally, the total data were collected from 15 detailed interviews apart from the initial community meetings. Discussions focused on disaster knowledge evolution, modification, and transmission within the community.

#### 5.2.2.2 Grounded theory approach

A grounded theory approach was used to find out the theoretical connections based on the study [54]. Furthermore, a continuous process was used to code the general themes. Grounded Theory Methodology (GTM) is a systematic, inductive and comparative approach for conducting research, where the purpose is to construct theory. The researcher maintains a constant reference to the data while being involved with the emerging analyses. Thus, the collection of data and its analysis proceed simultaneously, where each informs and optimizes the other. With the collected data, data analysis took place – with constant coding and comparison, which means taking the raw data to a conceptual level through a coding process [54, 153].

In this study, a continuous process was used to code the general themes. As summarized in (Table 5.1), the initial coding process started after gathering data in the community entry meetings with 4 participants, two from each village. Then, in-depth interviews were done with 9 participants in case study 01 and the data was transferred into memos. After continuing the open coding process with the detailed interview memos, the categories that are the axis of analysis could be defined by axial coding. After the data input, to continue the data collection process, one person was interviewed in case 01. During the interview, it was observed that there were no new ideas other than that of the previous nine interviews. Therefore, it was decided to move on to case 2. Thus, the survey was done in case 2 and had five detailed interviews. After the surveys, the detailed stories of six participants were finally used for selective coding, to refine the constituents of local knowledge development in the villages Etanwala and Mandaramnuwara. By coding the data, it was discovered that concepts, categories, themes and patterns and the links between them gave a sense and an explanation to the research problem statement.

#### 5.2.2.3 Household questionnaire surveys

Knowledge and information mainly flow through social connections, and the questionnaire surveys are the most common data collection method that researchers use to identify social connections in social studies [14, 148]. Therefore, this study

Table 5.1: Theoretical sampling and coding process.

| Date (mm/ yy) | Location | Type of Collected Data | Description | Data Analysis Methods |
|---|---|---|---|---|
| Feb/2 018 | Case study 1 & Case study 2 | Community entry meetings - memos | Initial community meeting with the responsible government officer in each village ("Grama Niladari"). As in any qualitative study, the researcher must have an approach to the region and its people.<br>Secondly, initial community meeting with one villager after the interviews with the government officer in each village. | Memo writing during and after each meeting. ***Open coding*** is used to read the information and identify the comments related to the primary categories. |
| Mar/ 2018 | Case study 1 | Detail Interviews | In-depth interviews with nine villagers of the Etanwala village. Participants were selected using snowball sampling technique. Most of them are former village leaders and elders. | Memo writing after each interview. Continue with the ***Open Coding***, and by ***Axial Coding***, categories that are the axis of analysis are defined. Use NVivo 12 for the identification of nodes or categories that are extracted from the discussions. |
| Dec/ 2018 | Case study 1 & Case study 2 | Detail Interviews | In-depth interviews with six villagers.<br>1 – Etanwala village<br>5 – Mandaramnuwara village<br>Participants were selected based on snowball sampling technique. | Mapping concepts and theoretical writing by constant comparing each category or node, and then integrating the categories and their properties for the ***Selective coding*** refines the concepts and themes. |

used a questionnaire survey to collect information on social connections, supporting disaster knowledge transfer. The target population included the participants in the villages. Social network data were collected through questionnaires completed through personal interviews to identify social ties. Data from various types of ties were collected to investigate diverse social networks. This study applied only the information and knowledge exchange network relating to local knowledge of landslide disasters. The survey questions and the survey plan were finalized after the initial community entry meetings. As previous studies have highlighted, in isolated communities, elders and village leaders act as knowledge keepers/cultural advisors [71,147]. Therefore, a list of community leaders and respective elders were collected - as the few candidates for question no 4 (Table 5.2) in the questionnaire survey, during community entry meetings.

For the first case study, 80 individuals were selected as the sample size using stratified random sampling and a questionnaire survey (Table 5.2). The sample included four categories of villagers based on different age groups: ten participants from 12 to 19 years, 22 from 20 to 39 years, 25 from 40 to 59 years, and 23

Table 5.2: Overview of questions asked to each respondent to collect network data.

| *Question Number* | *Question* | *Type of relation* |
|---|---|---|
| **Q1** | Personal information regarding age, gender, civil status, etc. | |
| **Q2** | If you need to know about any information, any changes, or any issues in the natural environment (like risk for natural disaster), e.g., landslides, rock falls etc., who would you discuss this with? Name persons | Information and knowledge exchange |
| **Q3** | Do you exchange information/experience with anyone regarding any changes or any issues in the natural environment? (Yes/No) If yes, name persons. | Information and knowledge exchange |
| **Q4** | Below is the list of five selected individuals named by the "Gramaniladari" officer on the initial discussions in the preliminary field survey in the village. Based on questions 4 and 5, can you tell us if you know them? If so, do you exchange information with them, and how often. | Information and knowledge exchange |

participants from more than 60 years group. The sample size selected for the second case consisted of 60 participants who were was selected using the same sampling technique as used for the first case study. The sample included 11, 17, 19, and 13 participants from the 16–19 years, 20–39 years, 40–59 years, and more than 60 years age groups. A social network within a village community is a three-dimensional reflection of the interaction patterns of an individual or a group. The configuration of a network structure determines the pattern of linkages among the network members [17, 129]. This study used centrality parameters to analyze the social network configuration in a network of rural communities.

## 5.3 Social network configurations

In this study, only the information and knowledge exchange networks related to natural disasters were applied. Degree and betweenness centrality parameters were calculated to investigate the centralization of the knowledge-transfer network. Respondents were grouped into four categories based on their age as mentioned previously and the centrality values of both the communities were calculated. All the names and personal details were kept confidential. Consequently, both the communities exhibited the same distribution pattern in centrality values. High degree of centrality scores were displayed by individuals in the age group over 60 years in both the networks, implying that the elderly group had a high level of social ties in local knowledge transfer. However, the scores varied from 0.152 to

Table 5.3: Degree centrality and Betweenness centrality.[DC = Degree Centrality Score BC = Betweenness Centrality Score]

| | | Etanwala village | | Mandaramnuwara village | |
|---|---|---|---|---|---|
| Age Category | | DC | BC | DC | BC |
| Age group (14 to 19 Years) | Heights | 0.139 | 0.008 | 0.153 | 0.010 |
| | Lowest | 0.063 | 0.001 | 0.068 | 0.000 |
| | Average | 0.105 | 0.004 | 0.111 | 0.004 |
| Age group (20 to 39 Years) | Heights | 0.291 | 0.038 | 0.373 | 0.081 |
| | Lowest | 0.127 | 0.006 | 0.136 | 0.007 |
| | Average | 0.217 | 0.022 | 0.243 | 0.027 |
| Age group (40 to 59 Years) | Heights | 0.266 | 0.039 | 0.339 | 0.056 |
| | Lowest | 0.139 | 0.011 | 0.169 | 0.010 |
| | Average | 0.202 | 0.021 | 0.245 | 0.026 |
| Age group (Over 60 Years) | Heights | 1.000 | 1.000 | 0.983 | 1.000 |
| | Lowest | 0.152 | 0.007 | 0.237 | 0.028 |
| | Average | 0.325 | 0.107 | 0.411 | 0.183 |

1.0 in the Etanwala community,

and from 0.237 to 0.983 in the Mandaramnuwara community (Table 5.3) because when individuals get old, trust and capacity to influence decreases. Hence, the average degree centrality scores were higher than the highest scores for all other age groups . The age group having individuals under 19 years had low degree centrality scores, with the average values ranging between 0.063 and 0.068. Although the over 60 years age group displayed the highest scores and the younger age group demonstrated the lowest scores, a positive trend in the degree centrality values was observed with age.

Betweenness centrality was calculated to determine the level of dominance of the individuals for local knowledge transfer within the community network. Similar to the degree centrality results, the elderly group displayed the highest betweenness centrality scores, with average values of 0.107 and 0.183 in the Etanwala and Mandaramnuwara communities, respectively (Table 5.3). Comparatively, participants under 60 years had lower centrality than the elderly group over 60 years in both communities . Therefore, based on the betweenness centrality scores, we can conclude that the elderly group was the dominant group in transferring local knowledge to the village network.

### 5.3.1 Social network configuration in etanwala village

According to the social network visualization shown in Figure 5.2, few participants exhibited high degree centrality and betweenness centrality values, indicating a strong linkage within the communities. The network configuration appeared as a highly centralized pattern, and few members played a key role in the community network. Among the elderly group, three individuals, who were farmers, dominated the knowledge sharing network. One individual was the present village leader, while the other two were former village leaders.

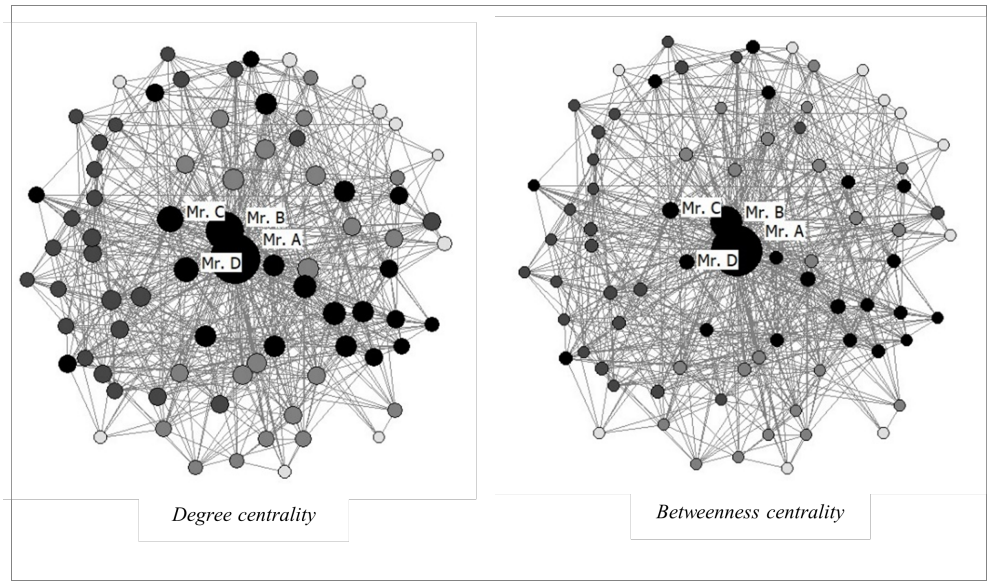



Figure 5.2: Social network structure of the Etanwala village

### 5.3.2 Social network configuration in mandaramnuwara village

Figure 5.3 depicts the social network diagrams of the Mandaramnuwara community. Each node represents an individual member in the network, and the size of the node varied with its respective centrality score. The social network pattern in the Mandaramnuwara community was also dominated by few individuals. The network configuration was similar to that of Etanwala community, where the elderly group played a key role in knowledge transfer within the network. Within the highly centralized network, approximately four individuals dominated

the knowledgesharing network, and all the four individuals have been village leaders at some point; one individual was the present village leader, while the rest were former village leaders. Additionally, three individuals were farmers, and one was an Ayurveda doctor.

Based on the results of the centrality parameters, the patterns of network configurations in both the communities were similar. By occupying specific central positions in a social network, actors can influence others in the network; approximately 3.0% of the individuals dominated the local knowledge transfer mechanism in both the communities.

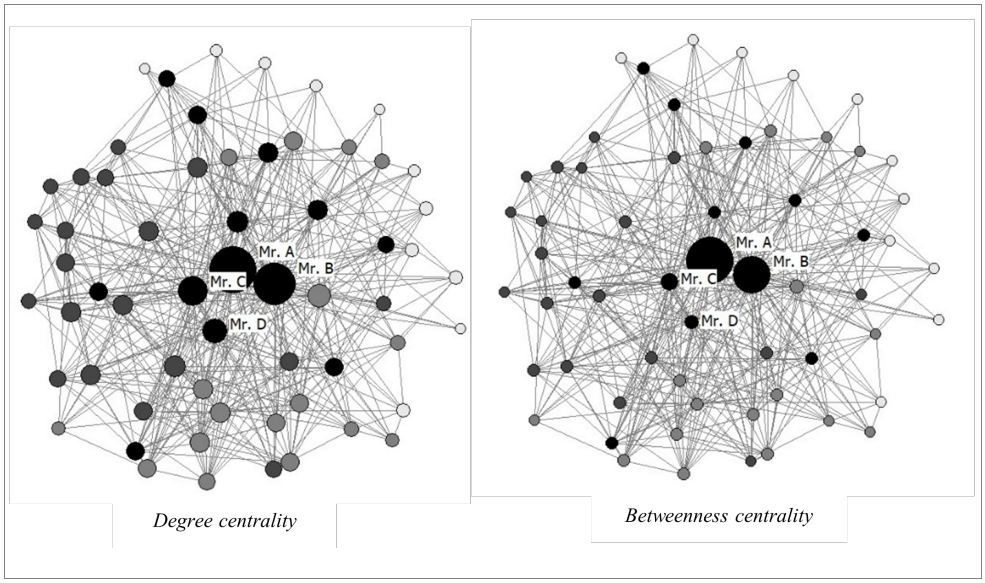



Figure 5.3: Social network structure of the Mandaramnuwara village

## 5.4 Empirical Findings

Detailed interviews were recorded and transferred to a memo and used for coding. Initial coding was undertaken after compiling the interview data into detailed memos using the NVivo 12 interface. The participants of the two villages provided detailed stories about their experiences with local knowledge development constituents. Careful reflection and analysis of the received data and the descriptions given by the participants, five themes were apparent: (i) vulnerability awareness, (ii) dependence on the unique culture, (iii) respect for human social hierarchy,

(iv) trust and feeling safe, and (v) stewardship ethics (Figure 5.4). The themes' detailed explanation was based on some parts of the interviews quoted as Example 01, Example 02 and Example 03. The first theme is Vulnerability awareness. All the participants had experienced at least one landslide disaster during their lives, which created awareness about landslides and disaster vulnerability through their realizations or the knowledge received from their forefathers. Moreover, Example 01 showed that their culture defines disasters in their terms and the all know landslide as 'Mada hena'.All the participants mentioned 'Mada hena' and the risk involved in those incidents (Figure 5.4).

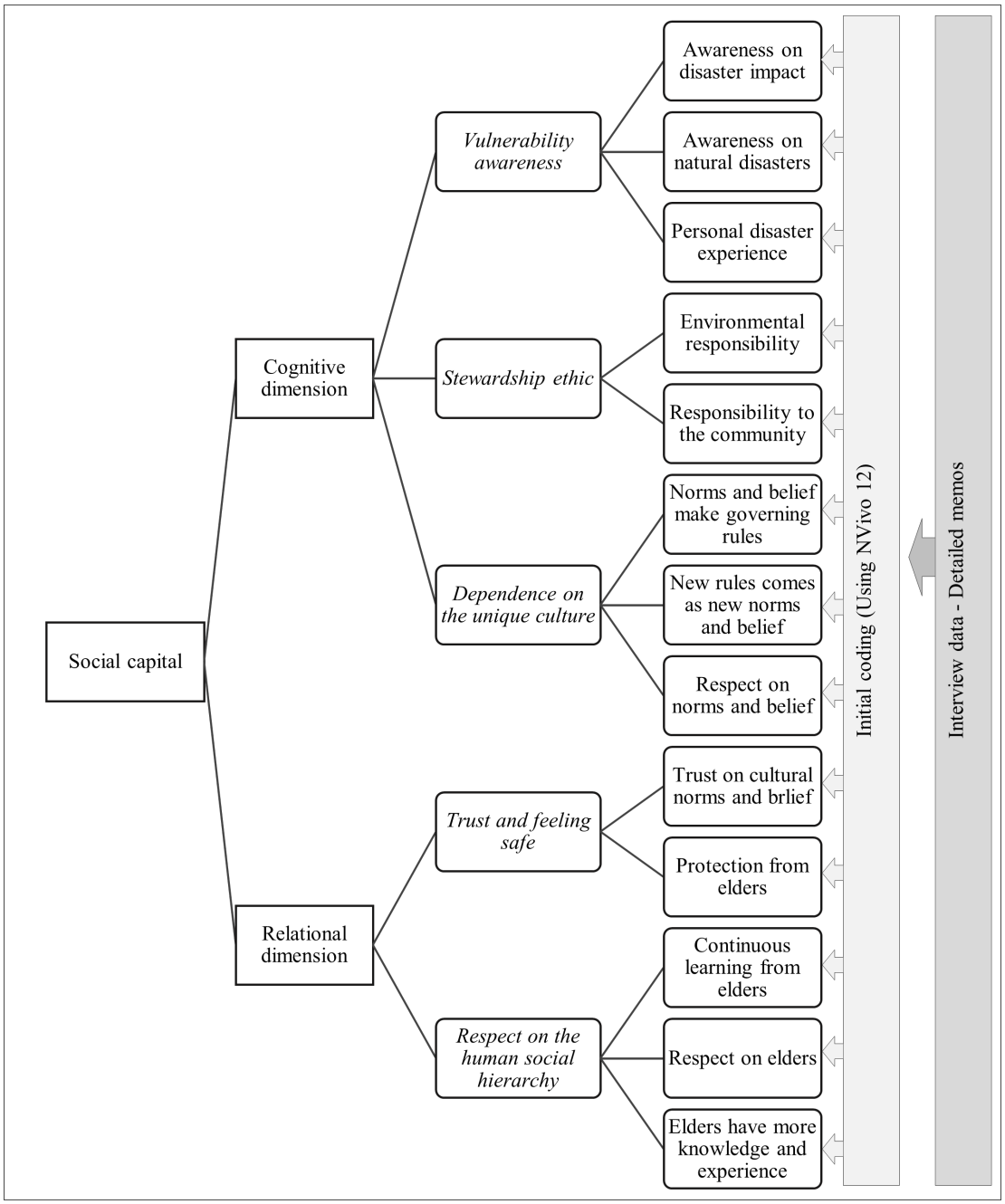



Figure 5.4: Relationship between codes and themes

Example 01. *[Mr. B, Case study 01] – "We know about natural disasters that can happen in our village from our childhood. We call disasters as 'Hena'. 'Hena' is a term that came from our ancestors. 'It's a deadly incident that can affect a terrible impact on society. All the people are scared of these incidents because of their beliefs derived from our unique culture. In our culture, we named these disasters in some special terms, floods – 'Diya hena' [ 'Diya' means water], Landslides –*

*'Mada hena' [ 'Mada' means Soil], Lightnings – 'Gini hena' [ 'Gini' means Fire]".*

Moreover, Norms and beliefs were the main controlling domains of the communities (Example 2). Each function within a community depended on its unique cultural norms and beliefs. Disaster knowledge, preventive actions, and related governing rules were defined based on their norms and beliefs. When the experts identified a new practice or new knowledge on disaster risk reduction, all explanations and definitions were based on their cultural norms and beliefs. This concludes their Dependence on the unique culture as second theme.

Example 02. *[Mr. A, Case study 02] – "When I was a child, we heard about 'Mada hena'. When I was nine, my family and relatives had suffered an enormous landslide due to continuous dense rain falling within a week. It came along with trees creepers, the large size of stones. At that time, we are doing cultivation above the housing area by clearing the forest cover. Because of clear land above the houses, the sliding mud and stoned directly come to the housing belt and destroy our houses."*

However, elders thought these 'hena' happened because they committed sins to the God in this region by clearing the forest. In the past, some called this devastating event as the God who belongs to the region and get angry 'Deviyo koopa wela'. Therefore, all people believed that if they can stop doing some bad things to the environment, it will help make God happy and protect them from disasters. Therefore, we started believing that clearing this forest makes God angry. Then our elders made a new rule by limiting the forest clearing. They made a forest area preserving for God, and as a result, the person who tried to destroy the forest without permission will get punished. Therefore, after announcing the rule, no one touched the forest which are above their houses. Moreover, it became a strong belief because no landslide happened after this landslide incident, and they all became to respect and are afraid of elders. We never do anything out of elders advice because they guide us and never do anything wrong in front of youngers.

Elders who have lots of experience made them experts in knowledge. The participants respected the elders since childhood, obeyed them, and followed their advice. They learned how to survive and tackle unexpected disaster incidents from their elders (Example 2 & 3). Since the knowledge was derived from experience, elders were experts. Additionally, none of the elders disrespected the younger generations. This emphasized the theme, Respect for the human social hierarchy. Adopting disaster risk reduction measures that were defined by their traditional norms and beliefs made the participants feel safe. Most of the participants felt secured under the protection of an elderly group. According to the story in Example 2, each participant believed in the traditional knowledge of the elders to solve unexpected issues and had confidence in the elders in making decisions based on their experiences for the community. Therefore, they are Trusted and feeling safe under the supervision of their elders.

Example 03. *[Mr. B, Case study 01] – "We use 'Attam kramaya' working together as a best practice which derived from our ancestors. Our ancestors surveyed by hunting and killing animals. They survived in a team and hunted together as a group. Therefore, the practices of hunting and survival passed from one generation to the next to improve knowledge from elders. The same method is used in doing all our village activities. This practice makes it easy to work as a team as well as to teach younger. Most of the time, I was learning by observing how elders were doing things. Nevertheless, I was got expert while engaging the work with the elders."*

Each decision is derived under their advice based on their norms and beliefs. Moreover, the community respects their decisions. Adopting a unique culture based on their norms and beliefs made the participants responsible for protecting the natural environment while engaging in sustainable solutions. Additionally, each individual took responsibility to protect their villages, communities, and cultures make all of them respect in Stewardship ethic.

## 5.5 Conclusion

Isolated communities adapted to landslide disasters have a unique local knowledge-sharing mechanism. The dimension of social capital of knowledge-sharing network is highly influenced by local knowledge sharing. Both the communities had highly centralized social network configurations, and their structural dimension was dominated by few community members. These members were knowledge experts who played a key role in knowledge evolution and transfer. Moreover, cognitive and relational dimensions, such as unique culture, social trust, and unique social relationships, including respect for human social hierarchy, facilitated smooth transfer of knowledge within the network members. In particular, these two communities use the locally called 'Attam kramaya' (Example 3) method for working as a team in all social and community activity within the village [42]. The same method is used in the case of an emergency as well. Therefore, this is the time that they mostly share their local knowledge and the knowledge related to disaster risk reduction that mainly resided in the elders/experts as tacit form.

In general, the findings indicate how the social capital of a network influences local knowledge transfer and how it is critical in enhancing the resilience of communities to landslide disasters. The two studied communities were self-sufficient and were not well-connected with outside communities, particularly those possessing with landslide risk reduction strategies. The study considers only network ties within the community. The lack of consideration of the outside connections can be a major limitation of this study, and the lessons learned from the case studies shed light on possible future research in investigating the broader range of network ties. This can serve as a key foundation for developing a hybrid approach comprising local knowledge and scientific knowledge to manage the risks associated with landslide disasters. Local knowledge and the mechanisms of knowledge transfer are the key strengths of these communities to adapt to landslide disasters. Therefore, other case studies should be examined in different landslide disaster contexts. Moreover, a broader range of social ties should be considered to ensure the necessary support from authorized groups to improve the strength of social capital in disaster-prone communities, thereby securing their sustainable survival.

# Chapter 6

# Conclusion

## 6.1 Introduction

Chapter six discusses the importance of the identified local knowledge adaptations and the impact of the social capital in local knowledge evolution and transfer in a network of rural communities coping with landslide disasters.

## 6.2 How Mountain Community Become Sustainable in the Landslide Disaster Context?

This community is living at a geographically isolated village in landslide prone area of Sri Lanka. However, they still enhanced their adaptation level to live without suffering from a major landslides disaster. Their main income is based on agriculture. They accomplish all the necessary sources from their own land [42]. It is well recognized fact that the main cause of landslides in Sri Lanka is due to human induced reasons [36], mainly the poor land use practices. In that context, it is evident from the survey findings that this community is consciously aware of the possible consequences that may arises from poor land utilization. Around 75% of the people in the area aware about the landslide risks and they always use landslide prevention practices when they aim to change the land use such as life fencing and stonewall for reducing soil failure. Further they adapt a unique land utilization pattern which prevent the probable landslide risks. They maintain

the land area into three portions, the upper area as forest reservation, the middle portion high above the flood plain area, as concentrated housings surrounded by tree belts, the lower area as the paddy fields in the terrace pattern having the benefits to prevent severe landslides. In addition, the overall awareness of the possibilities of landslides can be recognized as a tacit knowledge which transfer from one generation to another as a part of their value system.

## 6.3 The consensus of local knowledge on landslide disasters in mountain community Japan

All three communities in this study live in a mountain village in the landslide-prone area of Japan. Nevertheless, they still improved their adaptation to surviving without experiencing a significant landslides disaster. Local knowledge created on disaster experiences must be individually attained and explained by individuals and the community. The community members should understand to lessen their contact with the threats, which would be a direct and efficient approach to decrease disaster hazards and minimize landslides' impact . The interview results emphasized that the people living in these mountain villages have proper and well-developed local knowledge over landslide disaster adaptation. The area is primarily agricultural livelihood, and a reasonable amount of land was used for rice farming from the historic period. The individuals who engage in agriculture and have lived in this mountain community for an extended period acquire a sufficient amount of experience. The experience or the exposure to the stress from the natural environment like disasters make them develop their methods to living without disaster risk. However, the level of awareness varied with the level of experience and the exposure; the individuals who lived extended periods while engaged in farming have a high level of awareness over local knowledge on landslides, while individuals who live shorter periods and who did not engage in the farming show a low level of awareness. On average, all the community was well aware of the basics of the exposed disasters and the risk involved. In that context, it is evident from the survey findings that this community has a consensus of the local knowledge

on landslide disasters. Once consensus is reached, using local knowledge to address landslide disaster risk prevention might guarantee that the risk prevention measures achieved the community needs . All the community members have a consensus over different practices and believe in landslide disaster risk reduction. Further, they adopt unique practices and methods which prevent the probable landslide risks within their communities. The risk involved in different landuses, early indicators for landslide prediction, and best farming practices are the main critical aspects in which they are confident. Therefore, the consensus of the local knowledge on landslide disasters is the one main factor facilitating the sustainable future of these mountain communities. Moreover, depopulation and aging have directly affected the livelihood of these mountain communities. The research findings show that the one main issue is terrace abandonment, and the effect of terrace abandonment is the occurrence of degradation processes such as erosion. This subsequently leads to an increase in landslide risks. The community and some researchers found the critical condition facing these mountain communities; the issue remains the same and shows the condition moving to the worse in the future. This trend will direct a more vulnerable environment for livelihood with the effect of natural disasters like landslides. In summary, terrace abandonment and the reshaping of terrace lands happen because of the population depletion in these mountain communities. At present, the study three communities in a critical socio-economic condition with the potential risk from the living environment attached with landslide disasters; however, the consensus of the local knowledge on landslide disaster adaptations makes the condition controlled to some extent. Nevertheless the negative trend subsequently leads to an increase in landslide risks and affects the sustainable future of these mountain communities.

## 6.4 How Can We Use the Local Knowledge Findings in Improving Contemporary Disaster Landslide Prevention Practices

This In an era, which many parts of the world are facing the adverse effects of climate change [121], countries like Sri Lanka at the middle-income range always find the difficulties in establishing scientific based high-tech solutions for disaster management [146]. Further in most cases the usability of such initiatives are in vain due to the difficulties in embedding such solutions to the community level value systems. The overall consequences of this do not stands positively in overall disaster risk management process. This is never to undermine or under estimate the usefulness of such initiatives. In that context it is vital to recognize local knowledge-based adaptation practices and integrate them with scientific solutions to enhance the overall adaptation level for disasters. In overall context, such hybridization will yield more sustainable benefits than standalone scientific or local knowledge-based practices. More specifically this study revealed the possibility of incorporating such approach in dealing with very complex and unpredictable types of disasters including landslides.

## 6.5 Uniqueness of social capital in landslide disasters

According to the categorization of the National Building Research Organization of Sri Lanka, Etanwala and Mandaramnuwara communities lived in areas with a moderate level of landslide risk zone. Furthermore, both the villages were far from the city centers, and more than half of their periphery was covered by forests. Therefore, the two villages can be considered as geographically isolated communities. With low influence and connection with the outside world, the two communities have sustained their homeland for generations by adapting to landslide disasters. According to the literature, key spatial and non-spatial landslide adap-

tation measures were identified within these communities [42]. Moreover, the results of this study proved that the communities that adapted to landslide disasters exhibited the same configuration in the knowledge-sharing networks, specifically in landslide disaster knowledge.

According to Figure 5.2 and 5.3, both communities had a highly centralized social network. Within the highly centralized network, approximately three or four individuals were dominant in knowledge-sharing. Both the communities were predominantly agricultural, and the knowledge was received through experiences. Therefore, individuals with more experience were dominant in the networks. Thus, individuals over 60 years of age played a key role in the knowledge-sharing network in both the communities. The younger generation exhibited low centralized scores and the scores increased with age. This trend was observed because disaster knowledge was received through experience. The configurations of both the networks had the same centralized pattern and were unique to these disaster communities. Considering the cognitive dimensions of the social capital, all communities shared goals and cultures. According to the text coding analysis results, the unit culture and dependence of stewardship ethic were determined as the sets of values within the social capital of the two communities. Therefore, the communities had standard norms and beliefs and their own rules to govern them [90]. Each individual respected the culture. This quality of social capital was observed in both the communities. The relational dimension of social capital referred to trust and beliefs over individuals. According to the analysis, trust and feeling safe were among the other key themes highlighted in the social capital of the network. Therefore, their trust level and respect for their culture and value system was unique to their culture. Overall, the two communities displayed a unique quality in the social capital of their knowledge-sharing networks. The same configurations, cultural.

Thus, the two communities were unique in social capital based on the above investigated qualities of social capital in a network of local knowledge-sharing of landslide disasters.

## 6.6 Influence of social capital on evolution and transfer of local knowledge in a rural community

The local knowledge can be explained as tacit knowledge. However, different types of knowledge transfer work together and acquire knowledge by joining and observing the collective actions of knowledge experts. Moreover, the high network centralization and high density of network provide a foundation for local knowledge evolution and transfer in these two communities. Some studies have shown that a central position is used to improve governance for the entire community [68], where centrally positioned farmers are engaged in acquisition, development, and transfer of ecological knowledge to other individuals in their networks [95].

According to the study results, unique pattern and dimensions of social capital in a network can be observed in a rural mountain community that are sustainably adapted to landslide disasters. Highly centralized network patterns support the unique culture, social trust, and unique social relationships, such as respect for human social hierarchy that are conducive for a smooth transfer of local knowledge within the network members. Therefore, the uniqueness and strong qualities of social capital strongly influence the knowledge transfer mechanism. This is the fundamental theory behind the survival of these communities, which suffer from minor damage during landslide disasters.

The two communities reside in geographically isolated villages in landslide-prone areas of Sri Lanka. Thus, they enhanced their adaptation to major landslide disasters to avoid suffering from severe destruction. According to previous studies, identifying local knowledge-based adaptations for landslide disasters and the influence of social capital in local knowledge-sharing are important considerations, which are often neglected by researchers [69, 82, 90, 93]. Thus, identifying sustainable solutions and mechanisms of knowledge-sharing for landslides is essential.

Sustainable adaptation of communities to landslide disasters facilitates policy-makers to engage in disaster risk reduction. Disaster-related knowledge-sharing process within these communities has unique characteristics and is thus a signifi-

cant factor. Therefore, this unique quality of the social capital of disaster-related local knowledge-sharing network plays a substantial role in transferring knowledge within the groups. Therefore, this unique pattern could be identified in such similarly isolated communities subjected to landslide disasters. Such communities usually do not majorly accept external involvement or inputs. Therefore, the best approach is to transfer new information through the dominant group of the centralized network. The dominant group of knowledge experts will grasp the information and pass the acquired knowledge through knowledge-sharing. This ensures that the entire community receives the knowledge and perceives it positively based on the specific qualities of social capital. Therefore, policymakers and other responsible authorities must understand these qualities included in knowledge sharing mechanisms and use the centralized networks and qualities of the social capital to share new information or knowledge sustainably.

## 6.7 Difference between the cases in Sri Lanka and Japan

The study primarily considered case studies in Sri Lanka and Japan, located in landslide disaster risk zones. Since they lived with landslide risk for a long time, some of the local adaptations they used to live with disaster can be found. They have many experiences with their surrounding environment and understand the changing environment with practical matters. Furthermore, those people have lots of experience with disaster situations, and they have different types of knowledge, such as traditional, technical and historical knowledge about natural disasters. Therefore, they use better, faster and safer ways to respond to disasters with individual practices and combine with different levels of local community groups.
In the initial stage, the investigation was started in Sri Lanka. The study was conducted in one geographically isolated village named 'Etanwala' in Matale District and a moderately isolated village called 'Mandaramnuwara' in Nuwara Eliya District. A moderate-level risk area was selected to observe the adaptations, as in moderate-level hazard areas' settlements remain without large-scale landslide inci-

dents. People would not be resettled in another place; livelihood patterns depend on the surrounding environment. Therefore, the two villages from the central hilly region were selected as case studies based on the above factors.

On the other hand, the second phase of the investigation was done in Japan. It was conducted in and with the community of the one mountain village, Matsunoyama, located in Tokamachi City, Niigata Prefecture. The area falls under the risk zone for landslide disasters, making the community more vulnerable to natural disasters, especially landslides. Therefore, this study selected three communities in the Matsunoyama villages with a long history of landslides located in the shūraku division. Mizunashi Settlement, Shimo Kawate Settlement (a combination of Matsuguchi and Mioke areas), and Fujikura Settlement were selected for this study based on the advice of the officials in the Tokamachi city office.

The cases in both Sri Lanka and Japan have similarities and differences from the perspective of local knowledge adaptation in landslide disasters. The comparison of these cases can be explained in different aspects, like social context, economic context, environmental context, as well as social network context.

### 6.7.1 Social context

The demographic condition in different countries has significant differences. In Etanwala village, 59 families live in 48 houses. The total population is 154. The population below age 40 is 74, and the over 40 years age population is 80. On the other hand, Mandaramnuwara village has 203 people below age 40 and 120 people over age 40 years out of the total population is 323. According to the fact that the ageing population remains around 50% or lower in both cases in Sri Lanka. However, Matsunoyama in Japan experienced a 46.4% aging rate from 1975 until 2010, and the population decreased by more than half with 5,930 people in 1975 compared with the 2010 population of 2,542 people [53]. Therefore, a declining population and a high ageing rate can be observed as one of the main challenges Matsunoyama communities face today. This is one of the major differences in cases in Japan and Sri Lanka. Specially in Japan , The mountain communities were facing huge issue with lack of younger generation to continue the life in

their communities. The important knowledge that they acquire from their experiences living in those risk areas should be transferred to the younger generations to continue sustainability in the community as well as to preserve those valuable knowledge systems. However, In Sri Lankan context, Still the younger generation having the intention to live in those mountain villages, and they still learn landslide adaptation knowledge from their elders by working together. The method is specially called 'Attam Kramaya'.

### 6.7.2 Environmental and Natural Disaster context

The cases in Sri Lanka was located in two mountain district names Matale and Nuwara Eliya. The mountain ranges are young with unstable geology, steep slopes, and a difficult-to-predict climate. Because of that, those areas are more susceptible to natural disasters. Matale and Nuwara Eliya are the two most vulnerable districts for disasters out of ten hazard prone districts. Over the past two decades, the severity of landslide disasters increased in Sri Lanka's highland region. Landslide disasters in moderate level hazards in both Districts. Therefore, mitigation measures are critical to reducing the vulnerability of the affected people.

Matale consists of significant topographical features, climatic conditions and a wide range of minerals. This region geographically coordinates between 7° 28' 18" North and 80° 37' 28" East. The average area temperature is 26°C to 30°C and varies due to the year's climate variation. Matale is a region with significant rainfall. Even in the driest month, there is a lot of rainfall, and the area's annual rainfall is 1110 mm to 1400 mm. Old landslide deposits are activating during South West Monsoon. Due to its geographical, geological constitution and socio-economic characteristics, some areas are susceptible to the impacts of landslides.

Etanwala village is administratively named as Etanwala GN division within the Matale district, and more than 90% of the area is susceptible to landslides according to the landslide risk classification, which was done by National Building Research Organization Sri Lanka. According to the village landslide history, nearly two small scale landslides happened in the past. Mainly two types of landslides can be expected: in this area, and rockfall landslides. Therefore, based on the ge-

ographical, socio-ecological, and landslide risk factors, this village was selected for the case study one. The total land area is 42 km2. More than half of the area of the village is occupied by cultivation, about 84%. Around 14% of the area is with the forest, and only 2% is covered with housing. There is one main river called Kalu Ganga Black river that is the village's main water source for cultivation and domestic purposes. The river has separated the village from other areas and only has one bridge of 3-m width to cross.

Nuwara Eliya District is one district located in the hill country of Central province Sri Lanka. The presence of the high mountains and steep mountain slopes, as well as plenty of precipitation, occurred in the region, Nuwara Eliya District has suffered from the worst damage of landslide, increasing the numbers of affected persons and damage to houses. This region geographically coordinates between 7° 0' 0" North and 80° 45' 0" East. The average area temperature is 13°C to 19°C and varies due to the year's climate variation. Most of the part has Red Yellow later sols soil condition [50]. Due to its geographical, geological constitution and socio-economic characteristics, some areas are susceptible to the impacts of landslides.

Mandaramnuwara village is administratively named as Mandaramnuwara GN division within the Nuwara Eliya district. More than 80% of the area is susceptible to landslides according to the landslide risk classification, which was done by National Building Research Organization of Sri Lanka. According to the village landslide history, nearly two small and one medium-scale landslide happened in the past. Mainly one type of landslide can be expected in this area, and it is debris flow landslides. Therefore, based on the geographical, socio-ecological and landslide risk factors, this village was selected for case study two. The total land area is 37 km2. More than two-thirds of the village's area is occupied mainly by rice and vegetable cultivation. There is one main River called "Sudu" Ganga river, which is mainly used for domestic purposes. But the main water source of the village for cultivation is spring water.

In the other hand, Matsunoyama village in Japan comes under the risk zone of landslide disasters making the community more vulnerable to natural disasters,

especially landslides. For example, in April 1962, cracks appeared in Usagiguchi, and two years after that, a full extension of 3,600 meters in, an average of 900 meters width, and a total of around 850 hectares of land of the foot of Matsuyama mountain slipped and moved int northeastern direction toward Koido River. The slip consisted of 7 landslides surrounding Matsunoyama. As a result, casualties were 349.9 hectares of paddy field, 371 houses, four schools, 15 public facilities, 98 buildings, 5.4 km of prefectural road, and 14.8 km of town road [153]. Matsunoyama, primarily surrounded by young mountain ranges, possesses steep slopes with unstable geology and a harsh climate to predict. Some areas are incredibly prone to landslides as a result of the meteorological, geographical, and geological conditions and socio-economic characteristics.

More importantly, the cases in both countries have landslide risk; however, the landslides in Sri Lankan were mainly induced by heavy rainfalls. There is no other type of induce factor for landslides except human activities. In Japan, the landslides were mainly induced by two main reasons. The heavy rainfalls and earthquakes make the context more critical in Japan. Moreover, the mountain communities selected for this study were located in heavy snowfall. This is another crucial factor that makes the community more at risk for natural disasters. During the heavy snowfall season, the community was vulnerable to snow avalanches. Therefore, the mountain community is more at stake than the Sri Lankan context.

### 6.7.3 Local Knowledge Adaptation

Different types of structural and non-structural adaptations for landslide disasters were identified in both countries. Structural adaptations like stone walls can be observed in both contexts. However, the non-structural adaptations, such as the early warning system and the knowledge-transferring mechanism identified in Sri Lanka, were identical to those communities. In that case, Japanese cases were more exposed to modern society, and they already start using modern technologies. However, the elders in both cases strongly emphasize the value and importance of their local knowledge system, and they like to transfer those practices to younger generations. Knowledge transmission is still happening successfully in Sri Lankan

cases. Still, due to an ageing population and a lack of young people in Japanese communities, their valuable local knowledge systems are at risk of disappearing.

## 6.8 Key contribution of the study

Overall findings imply how the local knowledge-based practices and value system had enhanced the disaster resilience of this small community for landslide disasters in Sri Lanka. Even though the mountain communities in Japan are depopulated, and in a critical condition, they adapted well to the landslide disaster environment with a unique collection of local and traditional knowledge. The study reveals the unique term for landslide 'Noge' emphasizes how much the concept of landslide is embedded in their culture from their ancestors. Furthermore, the research findings indicate how the local knowledge-based practices had enhanced the disaster adaptation level of the community. Knowing the landslide risk involved in different landuses is the key to appropriate landuse planning. However the terrace abandonment and the new farming techniques made the farm land risk in landslides, the community well knowledged in best farming practices to reduce landslide risk. In addition, the community believes different phenomena as early indicators for landslide disasters; the continuous heavy rain and the earthquake as immediate indicators, the earth cracks and muddy springs as other indicators that can be used for landslide prediction.

Furthermore, the consensuses of the local knowledge showed us how well those best practices and beliefs are shared among individuals within villages. Therefore, the all three communities have a consensus of local knowledge, and it is essential for achieving safer livelihood as a unit. However, the transfer of local knowledge is directly affected by depopulation in these mountain communities, which can be leads to the disappearance of valuable local knowledge in the future.

Isolated communities adapted to landslide disasters have a unique local knowledge-sharing mechanism. The dimension of social capital of knowledge-sharing network is highly influenced by local knowledge sharing. Both the communities had highly centralized social network configurations, and their structural dimension was dom-

inated by few community members. These members were knowledge experts who played a key role in knowledge evolution and transfer. Moreover, cognitive and relational dimensions, such as unique culture, social trust, and unique social relationships, including respect for human social hierarchy, facilitated smooth transfer of knowledge within the network members. In particular, these two communities use the locally called 'Attam kramaya' (Example 3) method for working as a team in all social and community activity within the village [42]. The same method is used in the case of an emergency as well. Therefore, this is the time that they mostly share their local knowledge and the knowledge related to disaster risk reduction that mainly resided in the elders/experts as tacit form. In general, the findings indicate how the social capital of a network influences local knowledge transfer and how it is critical in enhancing the resilience of communities to landslide disasters. The two studied communities in Sri Lanka were self-sufficient and were not well-connected with outside communities, particularly those possessing with landslide risk reduction strategies.

## 6.9 Conclusion and Recommendations

In a summary local knowledge and consensuses are key strengths of these communities to adapt to landslide disasters environment. Therefore, the authorities should understand the value of the local knowledge for the sustainability of these mountain communities. Although modern scientific knowledge for disaster risk reduction is vital, it is essential to recognize the role of traditional and local knowledge in enhancing the resilience of local communities, especially in the context of depopulating mountain communities in Japan and mountain communities in Sri Lanka. The research findings initially highlighted the local knowledge in the disaster risk reduction process. Moreover, the findings can act as a key foundation for building a hybrid approach containing local knowledge and scientific knowledge to cope with the risks associated with landslide disasters.

Moreover,the lessons learned from the case studies shed light on possible future research in investigating the broader range of network ties. This can serve as a

key foundation for developing a hybrid approach comprising local knowledge and scientific knowledge to manage the risks associated with landslide disasters. Local knowledge and the mechanisms of knowledge transfer are the key strengths of these communities to adapt to landslide disasters. Therefore, other case studies should be examined in different landslide disaster contexts. Moreover, a broader range of social ties should be considered to ensure the necessary support from authorized groups to improve the strength of social capital in disaster-prone communities, thereby securing their sustainable survival.As a future study, this research can continue to analyze the impact of the identified local knowledge-based adaptation for landslide disaster risk reduction.

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# Academic Achievements

## Publications in peer-reviewed Journals

1. Uditha Akalanka Dasanayaka and Yoko Matsuda. A study on local knowledge in adaptation to landslide disasters in sri lanka. Engineering Journal, 23(6):501–509, 2019.

2. Uditha Dasanayaka and Yoko Matsuda. Role of social capital in local knowledge evolution and transfer in a network of rural communities coping with landslide disasters in sri lanka. International Journal of Disaster Risk Reduction, 67:102630, 2022.

3. Uditha Dasanayaka and Yoko Matsuda. Consensus of local knowledge on landslide hazard in depopulated mountain communities in japan–a case study on matsunoyama village. IDRiM Journal, 12(2):1–22, 2022.

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*Article*

# A study on local knowledge in adaptation to landslide disasters in Sri Lanka

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**Abstract.** Natural disasters are unforeseen events which occur at hydrologic, geologic, and atmospheric origins. The Policy-makers still rely on mitigation strategies based on scientific approaches. However, many scholars had emphasized the importance of incorporating local knowledge and related practices for disaster risk management. In that context, this study investigates the local knowledge in adaptation to mitigate the landslides disaster situations by studying a village in Sri Lanka which is located at the central region of Sri Lanka which is vulnerable for landslide disasters. Landslides is one of the severe types of disasters in hilly terrains and which cause to loss of lives and property damages especially in Asia region. This study employed the field surveys, questionnaire surveys and semi structured interviews for data collection. The findings of the research indicate how the local knowledge-based practices in settlement layout & planning, landscaping had enhanced disaster adaptation level of the community. Further the local knowledge-based value systems act as a strong mechanism in identifying early signs of landslide disasters. Finally, the paper discusses the possibilities of upscaling such local practices for mainstream disaster management practices.

**Keywords:** Landslides, local knowledge, adaptation, semi structured interviews.

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## 1. Introduction

The progressive increase of human activities in accordance with the rapid growth of population lead to complex and inter-linked environmental and societal worldwide issues. Natural disasters and climate change becomes the most common issues and the consequences are extremely diverse. Major disasters such as flood, landslide, earthquake, tsunami, and drought etc. are perplexing for prior prediction and can result the environmental degradation by reducing the capacity of environment to attain social and ecological needs. In many parts of the world, landslides/earth slips had become a major type of disaster which is triggered due to natural and human induced reasons. The downward movement of slope-forming material such as soil, boulder, weather rock, intact rock and composition of them, along with groundwater and surface water, driven by gravity and triggered by rise of groundwater, and/or other factors such as erosion and rainfall form the landslide. Depending upon the material, speed and form of movement, the relation with water, type of terrain it occurs, and the size or scale, landslide can be classified into various groups. Specifically, a landslide can be grouped into different types as falls, topples, slides, lateral spreads, flows, mass movements, creeps, collapse, cutting failures, rock falls, and complex of them [1].

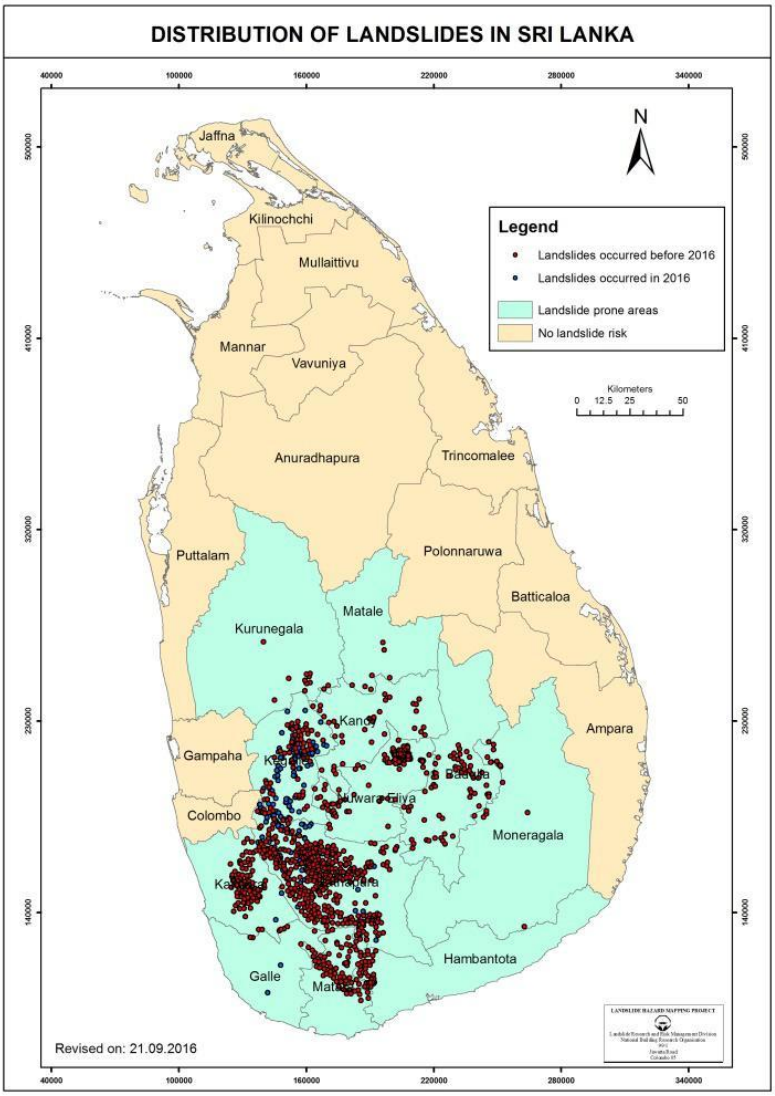


Fig. 1. Distribution of landslides occurrence before September 2016, in Sri Lanka.

In the recent years, landslides, floods and droughts are identified as most frequent and critical type of natural disasters in Sri Lanka [2]. Landslides are the most common and significant in central hilly terrains.

Badulla, Nuwara Eliya, Ratnapura, Kegalle, Kandy, Matale, Kalutara Districts located in the central hills region and Matara, Galle and Hambanthota Districts in the southern hills are identified as the landslide prone areas while approximately 20,000 km2 (37.7%) of land area is highly vulnerable for landslides. With gradual growth of demand in the development and expansion of human settlements, landslides play the major concern for the country's mountainous regions [3]. The rate of incidences and frequency of landslides are increasing. The density of the current landslide is estimated at around 1 to 2 landslides per square kilometre. Each and every rain, it is ordinary to happen one or two landslides or cutting failures. Landslides in Sri Lanka occurred not only due to natural causes but due to man-made causes [1]. Figure.1 shows the main landslide records up to the year 2016. The landslide disasters become the main threat to the countries like Sri Lanka. Therefore, identification of best solutions for minimizing landslide risk associated with the terrain is important for ensuring the sustainability of developments while minimizing the possible disasters due to landslides.

The contribution of indigenous local knowledge is the effective and useful disaster risk reduction intervention for identifying, assessing and monitoring disaster risks and enhancing the early warning for disaster risk reduction activities at the local level. Local knowledge contributes the large body of knowledge and skills developing at the outreach of the formal educational system [4]. The practice of using local knowledge is embedded in the society as a culture for long period of time. It helps and provides the basis for planning and decision-making for communities as in food securing, human and animal health, educational and natural resource management.

The practices of using indigenous knowledge as an early warning indicators for natural disasters are still widely used [4]. However, the Policy-makers still rely on mitigation strategies based on scientific approaches [5]. But some isolated mountain villagers still survived without any landslide damages with their local knowledge-based adaptations. Although there are more details about indigenous knowledge mitigations, the wealth of this knowledge has not been well-recognized in the process of disaster risk reduction. In addition, the scientific documentary evidences in Sri Lanka are very limited.

According to landslide risk levels, there are mainly three categories, high, moderate and low landslide risk zones. In high risk zones, the possibility of occurring the large-scale landslide is high and according to the records of the affected area recently suffered from it, it destroyed all settlement without remaining any object. Furthermore, the only possible solution for the affected areas having the high landslide risk is to abandon their area and move to the new location. However, the areas having the moderate level of risk may reduce the extent of vulnerability by practicing the effective landslide mitigation actions. This research is an attempt to investigate the local knowledge in adaptation to mitigate the landslide disaster situations based on moderate level landslide risk zone is described. These types of studies mainly use the reference with the case study approach [6]. For the study, Etanwala village in central region of Sri Lanka was selected for investigating their adaptation to landslide disasters.

The next section of the paper provides a detail account of the case study area and survey approach used in the research. Third section of the paper discuss how local knowledge-based practices enhanced the adaptation level of the community in dealing with different levels of disaster management cycle. Further latter part of the section discusses the possibilities of up scaling such local knowledge for mainstream disaster management practices. Final section concludes the main findings of the research while keeping a brief note on further research agenda.

## 2. Methodology

### 2.1. Case Study Area

The research study was conducted in one geographically isolated village named "Etanwala" in Matale District of Sri Lanka. This village is located in the central hilly region with a total population of 154 lived in 42 km2 administratively bounded region. This study area is under the moderate landslide risk zone.

This area has poor transportation system to get access easily. More than half of the area of the village is occupied by the cultivation about 84%. Around 14% of the area is with the forest and only 2% is covered with housings. There is one main river called Kalu Ganga Black River that is the main water source of the village for cultivation and domestic purposes. The river is separated the village with other area and only has three number of 3-m wide village to cross.

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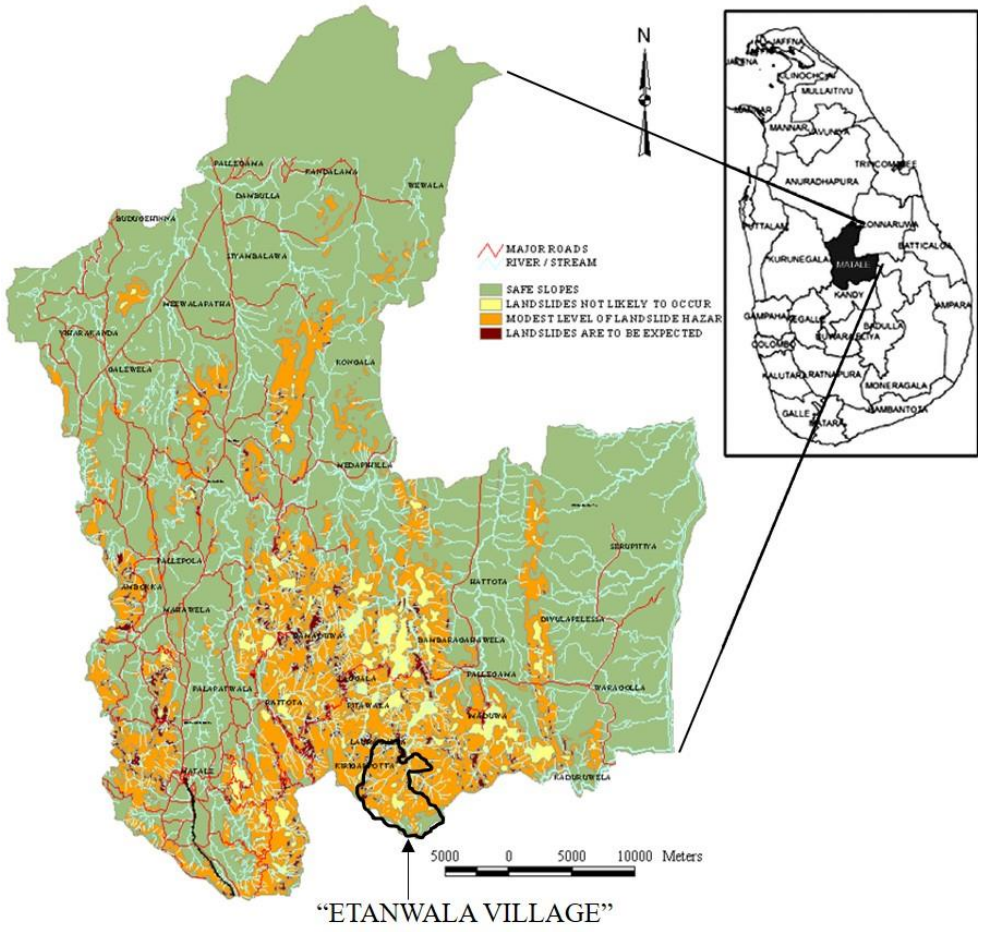


Fig. 2. Map of landslide hazard zones in Matale district Sri Lanka.

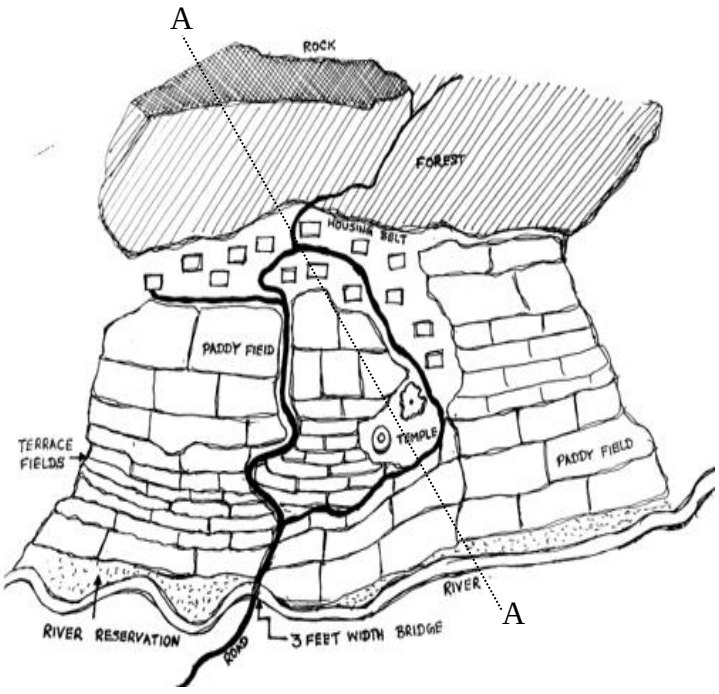


Fig. 3. Etanwala village layout integrating the forest, the temple, the terrace fields, and homestead. Conceptual. Source: Author.

### 2.2. Survey Method

For this study, the 80 sample population was selected using the snowball sampling technique [7] and conducted a questionnaire survey. The sample included four categories of villages based on their age, 10 candidates from 12 to 19 years age group, 22 from 20 to 39 years age group, 25 from 40 to 59 years age group and 23 candidates from more than 60 years old group who are dwelling in this village. Reason for carrying out the micro level study was to ascertain village's utility of their local knowledge on landslide disaster risk reduction. Since it does not completely capture all features of the local adaptations, semi-structured interviews were conducted with selected elders as well as with some relevant government officers. Percentage analysis was used to analyze the data.

## 3. Results and Discussion

For Eight local knowledge-based practices/actions related to landslide risk reduction were identified (Table 1). The respondents had known all the local knowledge-based practices by their own experiences.

More than three-fifths (69%) of villages are aware of the landslide risk that incurred in their life being in this isolated village. Two different observations actions were identified for the landslide risk prediction. Little more than one third (34%) of villages are aware of the unusual earth cracks are one best pre-indicator for landslide. While little more than four-fifths of villages were responded as continuous heavy rain may cause landslides. Early warning system is an essential component in disaster risk reduction. The village itself has a special method of passing emergency massages. It is embedded in their culture and more than four-fifths (93%) of villages are aware of the warning system based on temple bell.

Table 1. Level of awareness on adaptation actions.

| local knowledge based practices/actions | Respondents ( NO 80) | |
|---|---|---|
| | Number | % |
| Basic awareness on Landslides | 55 | 69% |
| Unusual earth cracks | 27 | 34% |
| Continuous heavy rain | 70 | 87% |
| Warning system based on temple bell | 74 | 93% |
| Practicing "Aththam Kramaya" | 38 | 47% |
| Terrace paddy fields / Forest reservation | 46 | 57% |
| Live fencing | 64 | 80% |
| Stone walls | 66 | 83% |

### 3.1. Basic Awareness on Landslides

Out of different types of natural disasters, landslides are the main disaster that occur frequently and having high potential to occur in this village. This village experienced small-scale landslides during past few years and the warning about the main landslide targeting to the part of the village was issued by National Building Research Organization. Based on above incident, most of the villages are well-aware about the landslide disasters and its initial phenomenon.

### 3.2. Early signs for Landslides

Nowadays, disaster prediction methods are effective and efficient with the most advanced technologies. But, the developing countries are still facing with the difficulties of accessing high technologies for disaster prevention program. In this case, the local knowledge regarding the early signs is very reliable and practical solutions for the local people. In this research, two main types of early signs regarding with the disaster prevention used by communities for the landslides are identified. The first type is unusual earth cracks which can be easily observed by checking the newly occurred cracks on ground. Using the above knowledge of early signs, local people can assume the area as high potential to landslides. The second one, continuous heavy rainfall, can make the changes to the ground water table by increasing the risks of severe landslides. The local people get cautions for the risks of landslide as soon as they notice the heavy continuous rainfall phenomenon for three or four days.

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### 3.3. Warning System Based on Temple Bell

The villagers have strong beliefs in cultural system. They all inherited all the beliefs and behaviors within their group and respect them. Temple is one of the most important and sacred place as religious beliefs for the group to deliver the important messages and decisions to them. Therefore, they use temple bells to give early prevention signs by ringing the bells. As the temple is located at the center of the area, the people can get easy access to the place and escape from the risks of the disaster when they notice the sound of the bells for emergency disaster prevention case.

### 3.4. Practicing "*Attam kramaya*" (Farming together)

This is derived from the traditional practices. Their main living depends upon cultivation of paddy and vegetables. As they always practice farming by gathering and working together, they can transfer their practices as the tacit knowledge. They always use this method effectively from one generation to another since many years ago. Therefore, the knowledge based on disaster prevention can transfer through this practice.

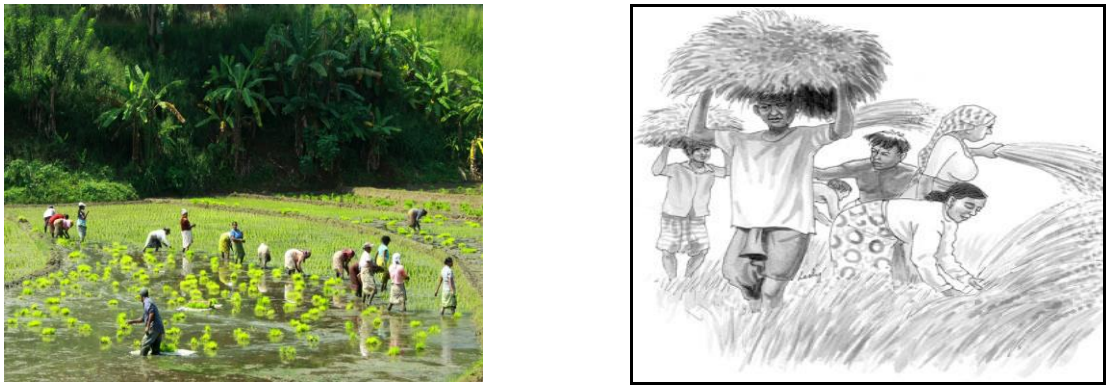

Fig. 4. Farmers planting paddy in waterlogged fields in Sri Lanka, Source: (Photo: cc: Denish C on Flickr) / Daily News Sri Lankas national newspaper 1918.

### 3.5. Specific Land Use Pattern

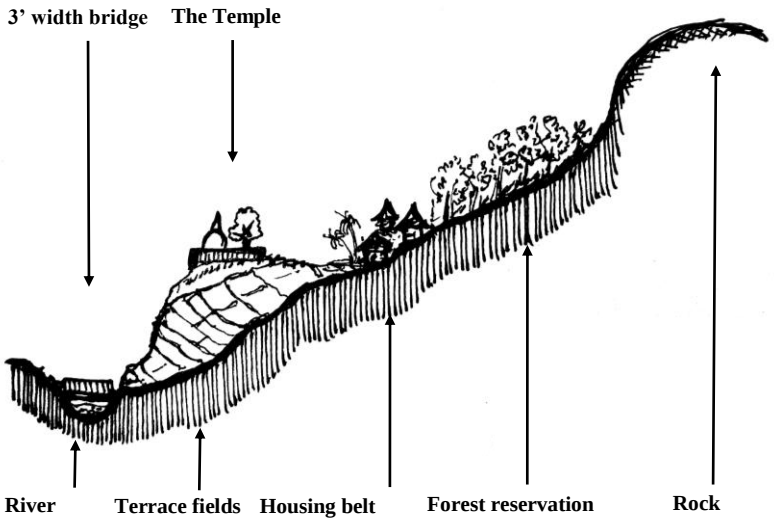


Fig. 5. Farmers Etanwala village profile, cross section of the village profile (Section A-A in Fig. 3) Source: Author

The respondents especially highlight effective pattern of land uses to prevent from the landslide hazard. Reservation of forest is one of the practices for the landslide hazards. Villagers reserve the forest in the upper region to prevent from the landslide. Specially, they plant and reserve the tree belts near their house in the upper side from the rock falls.

They built their houses in the uniform pattern within the belt to prevent deforestation. During the survey, they mentioned that terrace cultivation method is the most effective way for the prevention of landslide risks. As shown in Figure 5, the villagers are still using this specific pattern of reserving the forests in the upper slope and cultivating the paddy fields in the terrace pattern in the lower part in order to prevent the landslides.

### 3.6. Life Fencing and Stone Walls

Improving the soil strength and reducing soil erosion and also preventing landslide failure due to slope cutting, they use two types of techniques, life fencing and stone walls. For the life fencing, they use specific type of medicinal plant called Pawatta, Justicia adhatoda. It not only reduces landslide risks but also provides the indirect medicinal benefits. For the stone walls, they use their own techniques and use cost effective local materials. Those two methods have their own benefits and are easy to apply in local community.

Fig. 6. Pawatta plant used for making live fences.Source: Author.

Fig. 7. Retaining Walls. Source: Author.

From this survey, the eight actions are categorized and identified clearly for reducing the landslide risks for this community. These actions can provide advantages for the community and the awareness of these actions vary depending upon the Age groups. The following graph shows the different level of awareness for four Age groups.

Comparatively low awareness on "Unusual earth Cracks" in all four age groups with compared to other adaptation actions is shown in the figure 8. High awareness on both "Continuous heavy rain" and "Warning system based on temple bell" in all four Age groups with compared to other adaptation actions are described in the above graph. Age group of 12-19 years have very low awareness for all actions other

than "Continuous heavy rain" and "Warning system based on temple bell". As overall, the Age group over 40 years have comparatively high awareness on all type of adaptation actions.

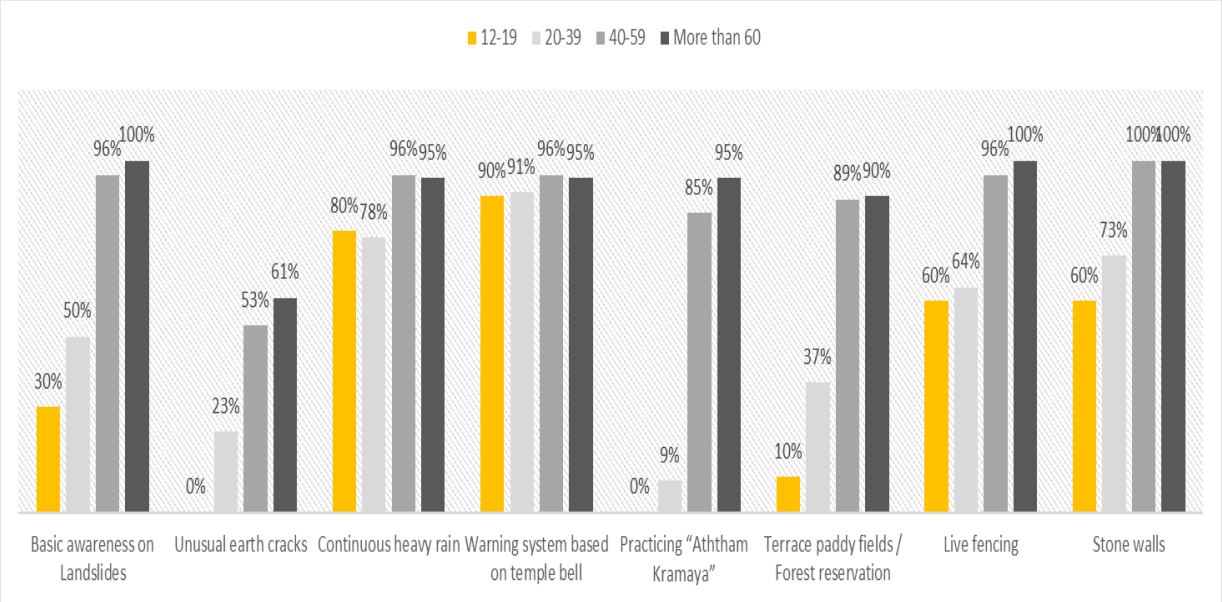


Fig. 8. Level of awareness on adaptation actions varied with different age groups, Source: Author.

### 3.7. How 'Etanwala' Become Sustainable in the Landslide Disaster Context?

This community is living at a geographically isolated village in landslide prone area of Sri Lanka. However, they still enhanced their adaptation level to live without suffering from a major landslides disaster. Their main income is based on agriculture. They accomplish all the necessary sources from their own land [8].

It is well recognized fact that the main cause of landslides in Sri Lanka is due to human induced reasons [9], mainly the poor land use practices. In that context, it is evident from the survey findings that this community is consciously aware of the possible consequences that may arises from poor land utilization. Around 75% of the people in the area aware about the landslide risks and they always use landslide prevention practices when they aim to change the land use such as life fencing and stonewall for reducing soil failure. Further they adapt a unique land utilization pattern which prevent the probable landslide risks. They maintain the land area into three portions, the upper area as forest reservation, the middle portion high above the flood plain area, as concentrated housings surrounded by tree belts, the lower area as the paddy fields in the terrace pattern having the benefits to prevent severe landslides.

In addition, the overall awareness of the possibilities of landslides can be recognized as a tacit knowledge which transfer from one generation to another as a part of their value system.

### 3.8. How Can We Use this Case Study Findings in Improving Contemporary Disaster Landslide Prevention Practices?

This In an era, which many parts of the world are facing the adverse effects of climate change [6], countries like Sri Lanka at the middle-income range always find the difficulties in establishing scientific based high-tech solutions for disaster management [10]. Further in most cases the usability of such initiatives are in vain due to the difficulties in embedding such solutions to the community level value systems.

The overall consequences of this do not stands positively in overall disaster risk management process. This is never to undermine or under estimate the usefulness of such initiatives. In that context it is vital to recognize local knowledge-based adaptation practices and integrate them with scientific solutions to enhance the overall adaptation level for disasters. In overall context, such hybridization will yield more sustainable benefits than standalone scientific or local knowledge-based practices.

More specifically this study revealed the possibility of incorporating such approach in dealing with very complex and unpredictable types of disasters including landslides.

## 4. Conclusion

As it is revealed in the third section of this paper, 69% of villagers are aware of the landslide risk that incurred in their life being in this isolated village. Further 34% of the population are aware of the unusual earth cracks are one best pre-indicator for landslide, while little more than four-fifths of villages were responded as continuous heavy rain may cause landslides. 93% of villagers are aware of the warning system based on temple bell. However, comparatively low awareness on "Unusual earth Cracks" in all four age groups with compared to other adaptation actions. High awareness on both "Continuous heavy rain" and "Warning system based on temple bell" in all four Age groups with compared to other adaptation actions. 12-19 years have very low awareness for all actions other than "Continuous heavy rain" and "Warning system based on temple bell". As overall, the Age group over 40 years have comparatively high awareness on all type of adaptation actions.

Overall findings imply how the local knowledge-based practices and value system had enhanced the disaster resilience of this small community for landslide disasters. Further, the lesson learnt from the case study shed light for further research and for developing hybrid approaches which comprised of local knowledge and scientific knowledge in managing the risk of landslide disasters.

Future step of this research intends to develop a comprehensive operational framework to implement hybrid approach based on scientific interventions and local knowledge-based practices in landslide disaster management. It is expected to carry out several case studies to investigate further best practices to achieve the said goal.

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# Role of social capital in local knowledge evolution and transfer in a network of rural communities coping with landslide disasters in Sri Lanka

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ABSTRACT

Landslide disasters occur suddenly, causing multiple socio-economic burdens on developing countries. Preserving and enhancing adapting capacity of locals to landslide disasters is a sustainable solution. Few villages are still sustainably surviving and dealing with the damages caused by landslides by adopting to local knowledge and subsequently, passing the knowledge to the next generations. Therefore, investigating social capital features and their influence on local knowledge transfer of landslide disasters is essential for preserving these valuable local knowledge systems. Thus, this study investigates the social capital features of Etanwala and Mandaramnuwara villages in Sri Lanka since the communities residing in these villages have effectively adapted to landslide disasters. In-depth interviews and questionnaire surveys were conducted to collect data related to social networks and other social capital dimensions. Social network analysis was conducted to determine the structural dimensions of these communities, and text data coding was performed with the acquired interview data to analyze the cognitive and relational dimensions. Consequently, the elderly group was found to be the dominant group in transfer of local knowledge within the networks. Moreover, the findings presented the influence and importance of social capital in preserving the local knowledge system of landslide disaster.

## 1. Introduction

Hydrometeorologically induced landslides are frequent natural hazards in Sri Lanka. Twenty percent of the landmass of the country includes mountains and hills. Since the country receives northeast and southwest monsoons and due to the rare unexpected extreme weather conditions, the country's central highland is vulnerable to landslide occurrences and thus suffers from severe destruction [1]. Consequently, the daily lives of the residents in the impacted areas are gravely affected. A recent understanding of the tectonics of the Indian Ocean region highlights the increased risk of earthquakes [2]. Therefore, the risk of landslides in Sri Lanka has been predicted to increase with the appearance of new triggers. Landslides mostly occur suddenly without any early indications, thus, making timely evacuation of people difficult [3]. Landslides have multiple vital global socio-economic implications. Progressively, multiple scientists agree that local knowledge can significantly reduce and manage environmental disaster risks, particularly in rural communities in developing countries [4–6].

Local knowledge is sometimes referred to as indigenous knowledge, traditional knowledge, or local ecological knowledge [7]. It serves as the foundation of all environmental solutions for problems related to agriculture, health care sector, food preparation, natural resource management, education, etc. Local knowledge has many knowledge levels; common indigenous knowledge is accessible to all community members regardless of age, gender, or social status; shared knowledge is held by many, but not all; whereas specialized knowledge is held by only few members, such as healers who have received special training [10]. It is unique and exists within communities indigenous to a particular geographic area [6,43,45,46]. Additionally, local knowledge plays a vital role in providing the basic techniques and strategies for disaster risk reduction [6] by majorly contributing to early warning systems and weather forecasting management [8]. Local knowledge mainly involves tacit knowledge [9,10], which resides in the human brain and cannot be easily acquired. The transmission of this valuable local knowledge from one person to another and from one generation to another is a key characteristic for ensuring sustainability of disaster-prone communities [11].

Knowledge transfer is a branch of knowledge management, focusing on the movement of knowledge across boundaries, which are created by specialized knowledge domains, by transferring knowledge from one

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place, person, or ownership to another [12]. Therefore, successful knowledge transfer results in receiving, accumulating, or assimilating new knowledge [10]. Knowledge sharing is a people-to-people process. Holden and von Kortzfleisch [13] explained the theory of translation [14]. It includes knowledge transfer as a networking activity. Networks provide individuals with access to knowledge, resources, or technologies. Through membership in a network and the resulting repeated and long-term knowledge exchange relationships, the network members create the potential for knowledge acquisition [10,11,15,16]. Recently, access to new sources of knowledge is one of the most important direct benefits of social capital [11]. Moreover, evidence suggests that knowledge transfer is facilitated by intensive social interactions of organizational actors [17].

Four decades ago, Granovetter [18] postulated social capital as a collective resource to attain knowledge flow through weak bridging ties. Since then, scholarly work linking social capital with knowledge transfer has received the attention of social researchers. Research on linking social capital and knowledge transfer had been focused on a few specific areas of interest with several researchers focusing on knowledge transfer in different network types [19–23]. Nonetheless, the majority of the existing literature is limited to knowledge transfer in a single network type [11,21]. A handful of researchers have validated the trust factor in networks and its impact on knowledge transfer [21,24]; but very few scholars have addressed the impact of social norms on knowledge transfer [25]. Some researchers have focused on the impact of networks on knowledge transfer and innovation [22,24,26]. Accordingly, past research accentuates that social capital plays a significant role in knowledge transfer.

The importance of social capital has been discussed in different disciplines – i.e. social science, economics, environmental management etc. Moreover, different researchers have identified social capital as a critical component of community resilience in the disaster risk reduction process [27–32]. Literature has focused on the dominance of social networks in disaster recovery [16], the positive and negative influence of social capital in disaster response and the need for context-specific cultural understanding of disaster response [29,33,34]. This is because social capital in disaster management appears to have differential effects for different people, depending on their particular socio-cultural context [30,34,35]. Entoh Tohani [36] investigated the role of social capital in a community that is highly vulnerable to eruption, and the study highlights that social capital covering values and norms, commitment, trust, networking and sharing of information or knowledge provides benefits in the form of increased community awareness of disaster, social solidarity, and disaster knowledge of the villages [36]. Sarita Panday's [37] study, focusing on the strength of social capital in disaster recovery based on the Nepal earthquake in 2015, emphasizes how bonding, bridging and linking social capital can influence the disaster recovery stage. Ananda Y. Karunarathne [38] investigated the evolution of social capital legacies in response to flood disasters in rural and urban areas in Sri Lanka. The findings reveal that social capital had evolved at different flood inundation phases, and played a vital role in recovering village livelihoods affected in past disaster events. Thus, bonding, bridging, and linking social capital helped reduce the adverse effects of past floods. Yong Lu etl [39] analyzed the information exchange in virtual communities under extreme disaster conditions, and this research has found that structural capital increases information quantity, whereas relational capital and cognitive capital increase information quality. However, some scholars argue that the inclusion of social capital into network analysis and knowledge transfer has not been discussed in the past literature sufficiently [20]; and also there are relatively few studies conducted in rural regions of developing countries [11,40,41]. Furthermore, none of the researchers have focused on the context of a rural community in a landslide disaster risk environment. In the Sri Lankan context, the unavailability of literature is critical, as this limits the opportunity to examine the multilevel view of social capital, and how knowledge is acquired and transferred in different social networks [42].

The evolution of knowledge and their subsequent transfer is an essential factor in preserving these valuable local knowledge systems. Many studies have been conducted to identify the adoption of local knowledge to address climate change, drought, typhoons, etc. [43]. However, few studies exist on the adoption of local knowledge for landslide disasters [8,44]. Despite these positive attributes, the possibility of integrating traditional and locally derived mechanisms into formal disaster risk-reduction strategies is low. Therefore, understanding these conventional disaster risk reduction mechanisms and the process of knowledge transfer is critically required [4,5,9]. However, few researchers have focused on analyzing the community's social networks, social capital, and disaster-related local knowledge transfer mechanisms in communities that are sustainably adapted to disasters [38,39]. Thus, a theoretical gap in research on the key concepts of social networks, social capital, and local knowledge transfer among network members associated with landslide disasters motivated the present research.

Subsequently, the aim of this research is to examine how the social capital dimensions of networks that affect the ability of a community to acquire local knowledge of landslide disasters from the network, and facilitate the transfer of knowledge among network members. The remainder of this paper is organized as follows. Literature review includes definitions of terms associated with the study. The research methods have been discussed in the next section. The research findings, which emphasize the role of social capital in local knowledge transfer for landslide disasters are presented in the fourth section. Finally, the conclusion includes discussions of the findings and provides future directives for further research.

## 2. Literature review

Overviewing the importance and meaning of various terms in the literature is necessary to develop a foundation for the research argument.

### 2.1. Adaptation

The terms "coping" and "adaptation" are used to describe the strategies deployed by community members in response to disasters. Generally, these terms have been used interchangeably [45]. "Coping" refers to the short-term and immediate measures implemented by individuals and communities, while "adaptation" involves livelihood progression beyond reactive responses. This study focuses on the long-term strategies and actions that have emerged and evolved in relation to landslide disasters. It argued that a community could adapt to landslide disasters if the community exhibited indigenous strategies and measures for landslide disaster risk reduction and if this knowledge was passed to their subsequent generations who resided in the same geographical areas, which were prone to landslide disasters [8].

### 2.2. Evolution and transfer of local knowledge

Local knowledge is shared and communicated among the community members orally; it is stored in people's memories and expressed as stories, songs, folklore, cultural beliefs, and rituals [8,46,47]. Local knowledge is acquired through personal observations and experience. Additionally, it is transferred through social networks, including learning from the older generations, natural resource management institutions, and discussions with experts [16,47]. Therefore, variation in the local knowledge of individual members is characterized by their livelihood practices, personal traits, and their ability to access information through their relationships with other members.

### 2.3. Adoption of local knowledge adaptations for landslide disasters

Landslides are ranked third worldwide among the most disastrous threats that require immediate attention since they cause extreme upheaval due to massive movement of landmass. However, identifying the best solutions for minimizing the risks to landslides associated with the terrain is vital for ensuring sustainable development while minimizing the possible occurrence of these disasters [46]. Local knowledge is an effective and useful disaster risk reduction intervention for identifying, assessing, and monitoring disaster risks and encouraging early warning for implementing local disaster risk reduction activities [8].

This study continuously identifies the best local knowledge adaptation practices and analyzes the role of social capital in transfer and evolution of local knowledge among different network members. The first step involves the identification of local knowledge adaptation practices for landslide disasters in Sri Lanka using two geographically isolated communities living in landslide risk areas, Etanwala and Mandaramnuwara, in Central Province of Sri Lanka. These communities have sustainably adapted to landslides and still continue to survive without suffering from any damages. Investigations were conducted in the two communities, and some of the investigated critical adaptation practices were [8]:

1. Developing early indications for landslides
2. Promoting a warning system using temple bell
3. Practicing "Attam kramaya" (Farming together)
4. Building live fences and stone walls

Unusual earth cracks, which can be easily observed by checking for new cracks on the ground, and continuous heavy rainfall were early indications of a possible occurrence of landslides. These two factors can change the groundwater table and increase the risks of severe landslides. The village temple is one of the most important and sacred places of religious beliefs and is also used to deliver critical messages and decisions. Therefore, the community rang temple bells as a system to warn, gather, and evacuate people.

Moreover, as the community members practiced farming by gathering and working together (Attam kramaya), they could transfer their practices as tacit knowledge. Live fencing (fencing with specific types of plants) and stone walls were used to improve soil strength, reduce soil erosion, and prevent landslides due to slope cutting (Fig. 1).

The transfer of this valuable knowledge is fundamental for the survival of these rural mountain communities. The knowledge transfer through social networks is highly dependent on social capital dimensions. Therefore, as a second step, this study investigated the influence of social capital on local knowledge evolution and transfer in communities prone to landslide disasters based on the results from the second phase of the study.

**Fig. 1.** Live fencing using pawatta (adhatoda vasica) plant and retaining walls. Source: Author.

### 2.4. Social capital and social capital dimensions

#### 2.4.1. Social capital

Social capital addresses the value of social connections in terms of competitive advantages derived from resources embedded in the social structure [11,48]. Woolcock [49] defined social capital as, "encompassing the norms and networks facilitating collective action for mutual benefit."

#### 2.4.2. Dimensions of the social capital

Nahapiet and Ghoshal [50] reported three social capital dimensions: structural, cognitive, and relational (Table 1). The structural dimension includes network ties, which are associated with specific actors. Ties are fundamental aspects of social capital because the social ties network of an actor creates opportunities for social capital transactions [10,16,47]. The configuration of a network structure determines the pattern of linkages among network members. Configuration elements, such as hierarchy, density, and connectivity affect the flexibility and ease of knowledge exchange through their impact on the extent of contact and accessibility among network members [10,11]. Furthermore, network stability is defined as the change in membership in a network. A precarious network may limit the creation of social capital opportunities because when an actor leaves the network, ties are broken [10,11].

The cognitive dimension represents the resources that provide shared meaning and understanding between the network members, and shared goals represent the degree to which network members share a common understanding and approach to achieve network tasks and outcomes. Members of an intercorporate network usually work towards a common goal. Depending on the network type, the tasks and outcomes regarding clarity and definition may vary. Furthermore, shared culture refers to the degree to which norms govern relationships. This factor is similar to tie modality, which is "the set of institutionalized rules and norms that govern appropriate behavior in the network. While these are sometimes spelled out informal contracts, most often they are simply understandings that evolve within the dyad and the network" [11].

The relational dimension focuses on direct ties between actors and the relationship instead of structural outcomes of interactions. Previous literature suggests that these relationships can be in the form of bonding, bridging, and linking social capital [41,51]. Bonding social capital connects individuals with a relatively high degree of homogeneity in terms of their socio-financial position and demographic characteristics within the community (for example, family, relatives, kinship groups) [28,34,35,37,52,53]. On the other hand, bridging social capital refers to connections between people who are not family, relatives or kin, but have similar financial status and political influence [28,52]. As a result of bridging, community members from across social divisions within a neighbourhood keep close relationships, irrespective of their ethnicities, geographical or occupational backgrounds. Moreover, linking social capital refers to connections between groups and people in positions of power (whether due to political position or financial resources) and includes vertical links to formal institutions, such as governmental organizations [28,37,52]. Among those different types of relationships, there are many dimensional factors such as trust, norms, and

**Table 1**
Dimensions of social capital.

| Social Capital | | |
|---|---|---|
| Structural dimension | Cognitive dimension | Relational dimension |
| - Network ties<br>- Network configuration<br>- Network stability | - Shared goals<br>- Shared culture | - Trust |

Source: *Nahapiet and Ghoshal 1998* [50].

identification; but this study has focused only on trust. Trust is a critical factor that affects inter-firm knowledge transfer and creation [11].

## 3. Materials and methods

### 3.1. Study area

The present study focuses on two communities located in the Matale and Nuwara Eliya districts in the central mountainous region of Sri Lanka. The districts are majorly surrounded by central mountain ranges, which are young, have unstable geology, steep slopes, and climate that is difficult to predict. Due to the meteorological, geographical, and geological conditions, and socio-economic characteristics, some regions are highly susceptible to landslides. Therefore, this study selected two communities residing in the Etanwala and Mandaramnuwara villages, which have a long history of landslides, and are located in the Grama Niladari division.

This study considers various aspects during the selection of case studies. It primarily assumes that the communities have already adapted to landslide disasters. Multiple reasons exist for considering this assumption. First, both communities have a history of landslides, but several generations still reside in the areas and have not changed their geographical locations. Second, spatial and non-spatial local adaptation measures for landslides were identified in both the communities. Therefore, this study assumes that Etanwala and Mandaramnuwara villages are sustainably adapted to landslide disasters.

#### 3.1.1. Introduction to case study 1 – etanwala village

Etanwala village is administratively named as the Etanwala Grama Niladari division within the Matale District. The total village land area is 42 $km^2$. The total population of the village is 154 individuals, with 59 families living in 48 houses. The village is approximately 11.76 km at a direct distance and 29.1 km by road from the city center of the nearest town, Rattota. However, its distance from the main city, Kandy, is 26.16 km directly and 64.1 km by road (Fig. 2). According to the distribution of land uses, more than 50% of the village is surrounded by forests. The community residing in this village is predominantly agricultural, mainly engaged in rice and vegetable cultivation. More than half of the area is cultivated (approximately 84%), approximately 14% of the area is covered with forests, and only 2% is covered with settlements. Kalu Ganga Black River is the primary water source used for cultivation and domestic purposes. The river separates the village from other areas and connects the village by a 3 m bridge. Furthermore, more than 90% of the village area is susceptible to landslides according to the landslide risk classification performed by the National Building Research Organization, Sri Lanka; additionally, two small-scale landslides have occurred in the village. Debris flow and rockfall landslides are the two types of landslides that can be expected in this area.

#### 3.1.2. Introduction to case study 2 – mandaramnuwara village

Mandaramnuwara village in the Nuwara Eliya District was selected as the second case study. It is located 16.81 km at a direct distance and 24.9 km by road from the city center of the nearest town, Hanguranketha. Moreover, it is 34.55 km at a direct distance and 56.7 km by road from Kandy (Fig. 2). The total village land area is 37 $km^2$. The total population is 323 individuals, with 112 families residing in 89 houses. More than two-thirds of the village area is covered by forests. According to the distribution of land uses, more than 70% of the area is surrounded by forests. Sudu Ganga River is the primary source of water used mainly for domestic purposes and cultivation. According to the landslide risk classification by National Building Research Organization, more than 80% of the area is susceptible to landslides. Nearly two small and one medium-scale landslides have occurred in the village. Debris flow type of landslides can be expected in this area.

### 3.2. Data collection and analytical methods

Interviews of the key informants, group discussions, and household surveys were conducted in both the village communities to collect data on social ties, and evolution and transfer of a constituent of traditional knowledge. Key informants were traditional knowledge holders or village leaders. The initial community meeting was done with the responsible government officers appointed to each village, identified as "Gramaniladari ": as in any qualitative study, it is a requirement that the researcher approaches the region and its people. Accordingly, two field visits were conducted in this study; and a preliminary field survey was conducted in early 2018. A household questionnaire was developed, based on the data obtained from the preliminary visit, to understand the network ties in knowledge sharing.

#### 3.2.1. Key informant interviews

After the initial community entry meetings in both communities, key informants were selected using a snowball sampling approach. Initially, the discussion was held with the 'Gramaniladari', appointed as a community officer in this village. After explaining the research purpose thoroughly, he was requested to list a few candidates for further interviews. A preliminary interview was conducted with one village elder named by the government officer, during the initial visit. The interview followed the same procedure to approach the second village. A detailed interview series commenced, with the persons listed by the community officer from the two villages. Nevertheless, at the end of each interview, the interviewees suggested the names of another suitable individual to have an interview with. Finally, the total data were collected from 15 detailed interviews apart from the initial community meetings. Discussions focused on disaster knowledge evolution, modification, and transmission within the community.

#### 3.2.2. Grounded theory approach

A grounded theory approach was used to find out the theoretical connections based on the study [54]. Furthermore, a continuous process was used to code the general themes. Grounded Theory Methodology (GTM) is a systematic, inductive and comparative approach for conducting research, where the purpose is to construct theory. The researcher maintains a constant reference to the data while being involved with the emerging analyses. Thus, the collection of data and its analysis proceed simultaneously, where each informs and optimizes the other. With the collected data, data analysis took place – with constant coding and comparison, which means taking the raw data to a conceptual level through a coding process [54–56].

In this study, a continuous process was used to code the general themes. As summarized in (Table 2), the initial coding process started after gathering data in the community entry meetings with 4 participants, two from each village. Then, in-depth interviews were done with 9 participants in case study 01 and the data was transferred into memos (Fig. 3). After continuing the open coding process with the detailed interview memos, the categories that are the axis of analysis could be defined by axial coding. After the data input, to continue the data collection process, one person was interviewed in case 01. During the interview, it was observed that there were no new ideas other than that of the previous nine interviews. Therefore, it was decided to move on to case 2. Thus, the survey was done in case 2 and had five detailed interviews. After the surveys, the detailed stories of six participants were

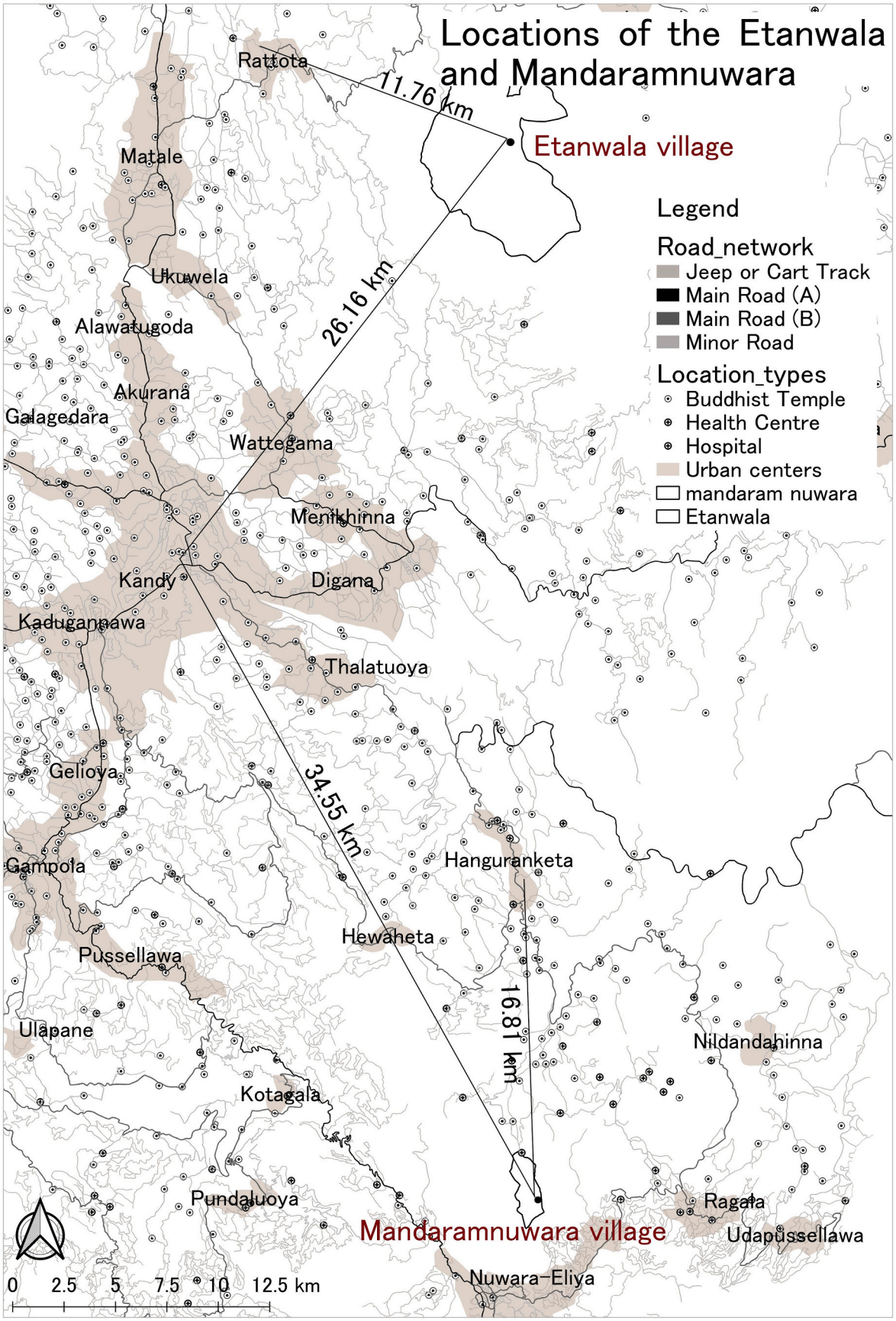


**Fig. 2.** Location map showing Etanwala and Mandaramnuwara villages.
Source: Survey department of Sri Lanka.

**Table 2**
Theoretical sampling and coding process.

| Date (mm/yy) | Location | Type of Collected Data | Description | Data Analysis Methods |
|---|---|---|---|---|
| Feb/2018 | Case study 1 & Case study 2 | Community entry meetings -memos | Initial community meeting with the responsible government officer in each village ("Grama Niladari"). As in any qualitative study, the researcher must have an approach to the region and its people.<br>Secondly, initial community meeting with one villager after the interviews with the government officer in each village. | Memo writing during and after each meeting.<br>***Open coding*** is used to read the information and identify the comments related to the primary categories. |
| Mar/2018 | Case study 1 | Detail Interviews | In-depth interviews with nine villagers of the Etanwala village.<br>Participants were selected using snowball sampling technique.<br>Most of them are former village leaders and elders. | Memo writing after each interview.<br>Continue with the ***Open Coding***, and by ***Axial Coding***, categories that are the axis of analysis are defined. Use NVivo 12 for the identification of nodes or categories that are extracted from the discussions. |
| Dec/2018 | Case study 1 & Case study 2 | Detail Interviews | In-depth interviews with six villagers.<br>1 – Etanwala village<br>5 – Mandaramnuwara village<br>Participants were selected based on snowball sampling technique. | Mapping concepts and theoretical writing by constant comparing each category or node, and then integrating the categories and their properties for the ***Selective coding*** refines the concepts and themes. |

**Fig. 3.** Interviews and initial group discussions.
Source: Author.

finally used for selective coding, to refine the constituents of local knowledge development in the villages Etanwala and Mandaramnuwara. By coding the data, it was discovered that concepts, categories, themes and patterns and the links between them gave a sense and an explanation to the research problem statement.

### 3.2.3. Household questionnaire surveys

Knowledge and information mainly flow through social connections, and the questionnaire surveys are the most common data collection method that researchers use to identify social connections in social studies [57–59]. Therefore, this study used a questionnaire survey to collect information on social connections, supporting disaster knowledge transfer. The target population included the participants in the villages. Social network data were collected through questionnaires completed through personal interviews to identify social ties. Data from various types of ties were collected to investigate diverse social networks. This study applied only the information and knowledge exchange network relating to local knowledge of landslide disasters. The survey questions and the survey plan were finalized after the initial community entry meetings. As previous studies have highlighted, in isolated communities, elders and village leaders act as knowledge keepers/cultural advisors [60–62]. Therefore, a list of community leaders and respective elders were collected - as the few candidates for question no 4 (Table 3) in the questionnaire survey, during community entry meetings.

**Table 3**
Overview of questions asked to each respondent to collect network data.

| Question Number | Question | Type of relation |
|---|---|---|
| Q1 | Personal information regarding age, gender, civil status, etc. | |
| Q2 | If you need to know about any information, any changes, or any issues in the natural environment (like risk for natural disaster), e.g., landslides, rock falls etc., who would you discuss this with? Name persons | Information and knowledge exchange |
| Q3 | Do you exchange information/experience with anyone regarding any changes or any issues in the natural environment? (Yes/No) If yes, name persons. | Information and knowledge exchange |
| Q4 | Below is the list of five selected individuals named by the "Gramaniladari" officer on the initial discussions in the preliminary field survey in the village. Based on questions 4 and 5, can you tell us if you know them? If so, do you exchange information with them, and how often. | Information and knowledge exchange |

For the first case study, 80 individuals were selected as the sample size using stratified random sampling and a questionnaire survey (Table 3). The sample included four categories of villagers based on different age groups: ten participants from 12 to 19 years, 22 from 20 to 39 years, 25 from 40 to 59 years, and 23 participants from more than 60 years group. The sample size selected for the second case consisted of 60 participants who were was selected using the same sampling technique as used for the first case study. The sample included 11, 17, 19, and 13 participants from the 16–19 years, 20–39 years, 40–59 years, and more than 60 years age groups. A social network within a village community is a three-dimensional reflection of the interaction patterns of an individual or a group. The configuration of a network structure determines the pattern of linkages among the network members [15,63]. This study used centrality parameters to analyze the social network configuration in a network of rural communities.

### 3.2.4. Centrality parameters

Various methods exist to define and measure centrality in social networks. However, in this study, we focus on two important and distinct types of centrality: degree and betweenness [64]. For this study, village inhabitants are considered nodes in a network of social relations relevant to knowledge transfer. A node's degree centrality is simply a count of how many social connections it has [65]. Betweenness centrality is a person's role in allowing information to pass from one part of the network to another [66]. Higher values indicate that the node is more central for degree centrality, showing the number of connections a person has [65]. Therefore, in this study, degree centrality values are used to identify the individuals who have more connections or are dominant in the knowledge sharing network. They may be connected to many people at the heart of the network, but they might also be some other nodes that do not have a very high degree but can play a prominent role in allowing information to pass from one part of the network to the other [66]. Therefore, this study has used betweenness centrality

values to capture the nodes, which are very important to the flow of information through a knowledge-sharing network. The betweenness centrality is simply a measurement of how it allows information to pass from one part of the network to the other. Thus, Degree centrality and Betweenness centrality are used to identify dominant nodes and derive the network structure of the knowledge sharing network in a rural community.

*3.2.4.1. - Degree centrality.* Degree centrality defines the number of edges/ties connected to a node [67]. The measure expresses the extent to which a node contacts and directly affects the network. The initial formula of degree centrality (*Cd*) of node *Ni* is given in Equation (1). However, the size of the network may vary. Thus, to reduce the possible size effect on *Cd* measurement, Wasserman et al. standardized Equation (1) and proposed a new measurement (*C'b*) method, which is given in Equation (2) to estimate the number of links directly connected to node *N* [64].

$$Cd(Ni) = \sum_{j=1}^{n} Xij_{(i \neq j)} \tag{1}$$

$$C^{'}d(Ni) = \frac{\sum_{j=1}^{n} Xij_{(i \neq j)}}{(n-1)(n-2)} \tag{2}$$

*Cd (Ni)*: Degree centrality of node Ni.
*C'd (Ni)*: Standardized degree centrality of node Ni.
$X_{ij}$: Number of edges per individual
*n*: Number of nodes in the focal network.

The *C'd* (Ni) value varies with the number of links, and ranges between 0 and 1 [64]. A value close to 0 indicates that the nodes do not have knowledge-sharing links, whereas a value close to 1 indicates that the nodes have multiple links. Subsequently, a node with a high *C'd* (*Ni*) value represents the dominant character of the network.

*3.2.4.2. - Betweenness centrality.* Betweenness centrality (*Cb*) is a measure of a person's role in passing information from one section of the network to another. Betweenness measures the importance of the node in information flow through a network. The basic formula of *Cb* is given in Equation (3). Wasserman et al. standardized *Cb* (*C'b*) by dividing it by (*n* - 1) (*n* - 2)/2; the subsequent standardized formula is given in Equation (4). In the two equations, *Cb* is the number of nodes (*N*) between any other two nodes in the network [64].

The betweenness centrality (*Cb*) of *Ni* is defined as:

$$Cb(Ni) = \sum_{j<k} \frac{G_{j,k}(Ni)}{G_{j,k}} \tag{3}$$

$$C^{'}b(Ni) = \frac{2\sum_{j<k} \frac{G_{j,k}(Ni)}{G_{j,k}}}{(n-1)(n-2)} \tag{4}$$

*Cb (Ni)*: Betweenness centrality of node *Ni*.
*C'b (Ni)*: Standardized betweenness centrality of node *Ni*.
$G_{jk}$: Number of shortest paths between *Nj* and *Nk*.
$G_{jk}$ *(Ni)*: Number of shortest paths between *Nj* and *Nk* that pass through *Ni*.

The *C'b (Ni)* value can vary from 0 to 1. A value close to 0 indicates that the node does not assist the flow of knowledge through the network, whereas a value close to 1 indicates that the node is crucial in knowledge flow in the network. A node with a high *C'b (Ni)* value represents the dominant character within the network.

## 4. Results and discussions

The data collected during field visits were analyzed using social network analysis and text coding (grounded theory approach). The questionnaire data were used to analyze the social network and structural dimensions of social capital in the two communities. UCINET 6 software developed by Lin Freeman, Martin Everett, and Steve Borgatti was used to calculate the centrality parameters and draw graphical diagrams of social network configurations. Furthermore, informant interview data were analyzed using NVivo 12 software to investigate the cognitive and relational dimensions of social capital.

### 4.1. Social network configurations

In this study, only the information and knowledge exchange networks related to natural disasters were applied. Degree and betweenness centrality parameters were calculated to investigate the centralization of the knowledge-transfer network. Respondents were grouped into four categories based on their age as mentioned previously and the centrality values of both the communities were calculated. All the names and personal details were kept confidential. Consequently, both the communities exhibited the same distribution pattern in centrality values.

High degree of centrality scores were displayed by individuals in the age group over 60 years in both the networks, implying that the elderly group had a high level of social ties in local knowledge transfer. However, the scores varied from 0.152 to 1.0 in the Etanwala community, and from 0.237 to 0.983 in the Mandaramnuwara community (Table 4) because when individuals get old, trust and capacity to influence decreases. Hence, the average degree centrality scores were higher than the highest scores for all other age groups (Figs. 4 and 5). The age group having individuals under 19 years had low degree centrality scores, with the average values ranging between 0.063 and 0.068. Although the over 60 years age group displayed the highest scores and the younger age group demonstrated the lowest scores, a positive trend in the degree centrality values was observed with age.

Betweenness centrality was calculated to determine the level of dominance of the individuals for local knowledge transfer within the community network. Similar to the degree centrality results, the elderly group displayed the highest betweenness centrality scores, with average values of 0.107 and 0.183 in the Etanwala and Mandaramnuwara communities, respectively (Table 4). Comparatively, participants under 60 years had lower centrality than the elderly group over 60 years in both communities (Figs. 6 and 7). Therefore, based on the betweenness centrality scores, we can conclude that the elderly group was the dominant group in transferring local knowledge to the village network.

#### 4.1.1. Social network configuration in etanwala village

According to the social network visualization shown in Fig. 8, few participants exhibited high degree centrality and betweenness centrality values, indicating a strong linkage within the communities. The network configuration appeared as a highly centralized pattern, and few members played a key role in the community network. Among the elderly

**Table 4**
Degree centrality and Betweenness centrality.

| | | Etanwala village | | Mandaramnuwara village | |
|---|---|---|---|---|---|
| Age Category | | DC | BC | DC | BC |
| Age group (14–19 Years) | Heights | 0.139 | 0.008 | 0.153 | 0.010 |
| | Lowest | 0.063 | 0.001 | 0.068 | 0.000 |
| | Average | 0.105 | 0.004 | 0.111 | 0.004 |
| Age group (20–39 Years) | Heights | 0.291 | 0.038 | 0.373 | 0.081 |
| | Lowest | 0.127 | 0.006 | 0.136 | 0.007 |
| | Average | 0.217 | 0.022 | 0.243 | 0.027 |
| Age group (40–59 Years) | Heights | 0.266 | 0.039 | 0.339 | 0.056 |
| | Lowest | 0.139 | 0.011 | 0.169 | 0.010 |
| | Average | 0.202 | 0.021 | 0.245 | 0.026 |
| Age group (Over 60 Years) | Heights | 1.000 | 1.000 | 0.983 | 1.000 |
| | Lowest | 0.152 | 0.007 | 0.237 | 0.028 |
| | Average | 0.325 | 0.107 | 0.411 | 0.183 |

DC = Degree Centrality Score.
BC = Betweenness Centrality Score.

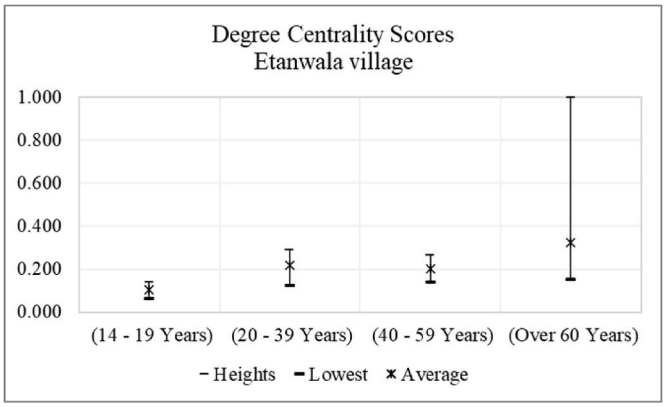


**Fig. 4.** Degree centrality scores - Etanwala village.

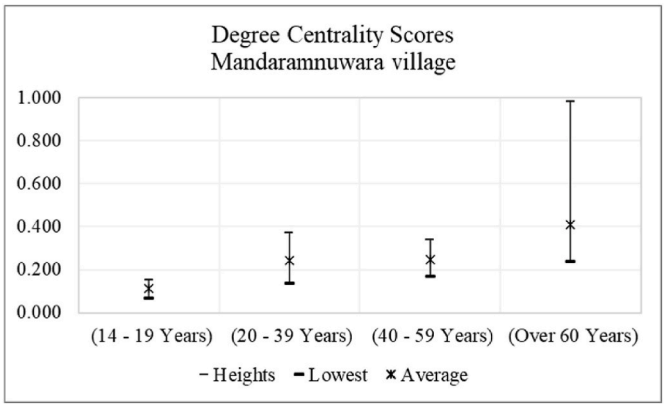


**Fig. 5.** Degree centrality scores - Mandaramnuwara village.

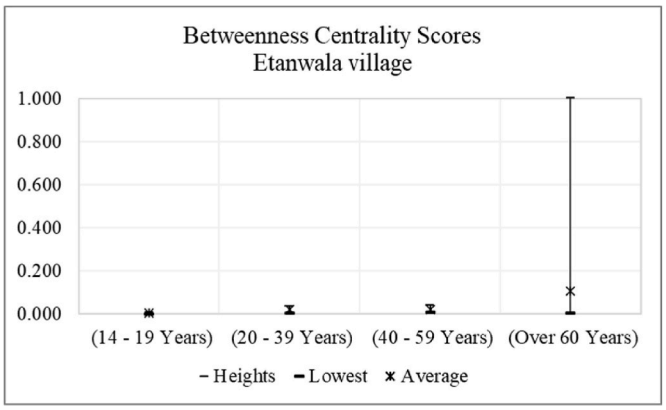


**Fig. 6.** Betweenness centrality scores - Etanwala village.

group, three individuals, who were farmers, dominated the knowledge-sharing network. One individual was the present village leader, while the other two were former village leaders.

#### 4.1.2. *Social network configuration in mandaramnuwara village*

Fig. 9 depicts the social network diagrams of the Mandaramnuwara community. Each node represents an individual member in the network, and the size of the node varied with its respective centrality score. The

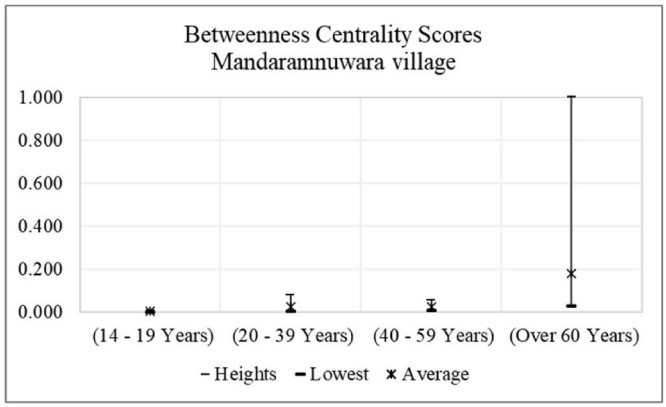


**Fig. 7.** Betweenness centrality scores - Mandaramnuwara village.

social network pattern in the Mandaramnuwara community was also dominated by few individuals. The network configuration was similar to that of Etanwala community, where the elderly group played a key role in knowledge transfer within the network. Within the highly centralized network, approximately four individuals dominated the knowledge-sharing network, and all the four individuals have been village leaders at some point; one individual was the present village leader, while the rest were former village leaders. Additionally, three individuals were farmers, and one was an Ayurveda doctor.

Based on the results of the centrality parameters, the patterns of network configurations in both the communities were similar. By occupying specific central positions in a social network, actors can influence others in the network; approximately 3.0% of the individuals dominated the local knowledge transfer mechanism in both the communities.

### 4.2. *Interview results*

Detailed interviews were recorded and transferred to a memo and used for coding. Initial coding was undertaken after compiling the interview data into detailed memos using the NVivo 12 interface.

The participants of the two villages provided detailed stories about their experiences with local knowledge development constituents. Careful reflection and analysis of the received data and the descriptions given by the participants, five themes were apparent: (i) vulnerability awareness, (ii) dependence on the unique culture, (iii) respect for human social hierarchy, (iv) trust and feeling safe, and (v) stewardship ethics (Fig. 10). The themes' detailed explanation was based on some parts of the interviews quoted as Example 01, Example 02 and Example 03. The first theme is *Vulnerability awareness.* All the participants had experienced at least one landslide disaster during their lives, which created awareness about landslides and disaster vulnerability through their realizations or the knowledge received from their forefathers. Moreover, Example 01 showed that their culture defines disasters in their terms and the all know landslide as "Mada hena".All the participants mentioned "Mada hena" and the risk involved in those incidents (Fig. 3).

**Example 01**. [Mr. B, Case study 01] – "We know about natural disasters that can happen in our village from our childhood. We call disasters as "Hena". "Hena" is a term that came from our ancestors. 'It's a deadly incident that can affect a terrible impact on society. All the people are scared of these incidents because of their beliefs derived from our unique culture. In our culture, we named these disasters in some

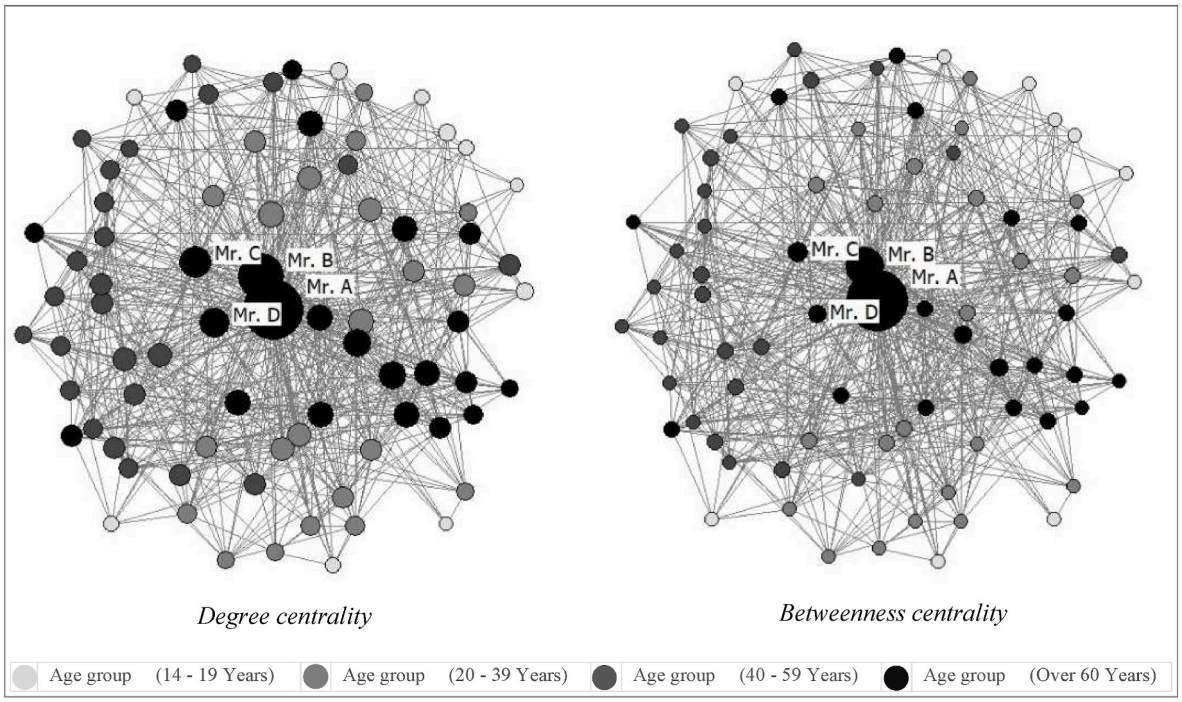


**Fig. 8.** Social network structure of the Etanwala village.

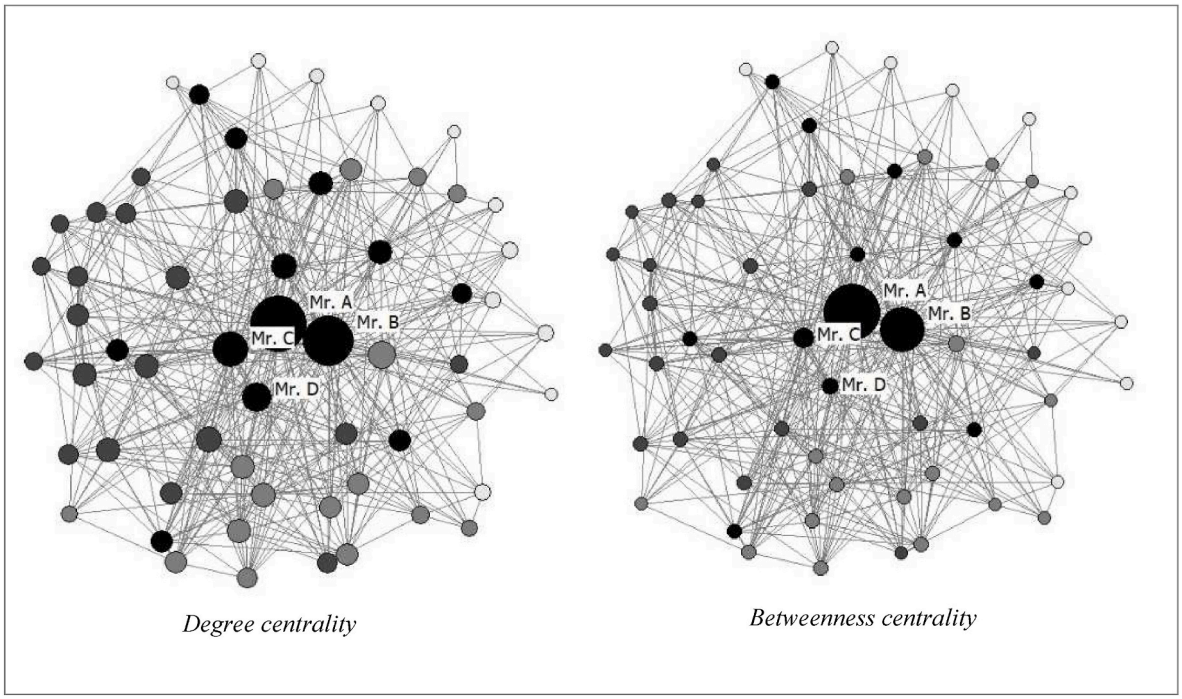


**Fig. 9.** Social network structure of the Mandaramnuwara village.

special terms, floods – "Diya hena" [ "Diya" means water], Landslides – "Mada hena" [ "Mada" means Soil], Lightnings – "Gini hena" [ "Gini" means Fire]".

Moreover, Norms and beliefs were the main controlling domains of the communities (Example 2). Each function within a community depended on its unique cultural norms and beliefs. Disaster knowledge, preventive actions, and related governing rules were defined based on their norms and beliefs. When the experts identified a new practice or new knowledge on disaster risk reduction, all explanations and definitions were based on their cultural norms and beliefs. This concludes their ***Dependence on the unique culture*** as second theme.

**Example 02**. [Mr. A, Case study 02] – "When I was a child, we heard about "Mada hena". When I was nine, my family and relatives had suffered an enormous landslide due to continuous dense rain falling within a week. It came along with trees creepers, the large size of stones. At that time, we are doing cultivation above the housing area by clearing the forest cover. Because of clear land above the houses, the sliding mud and stoned directly come to the housing belt and destroy our houses.

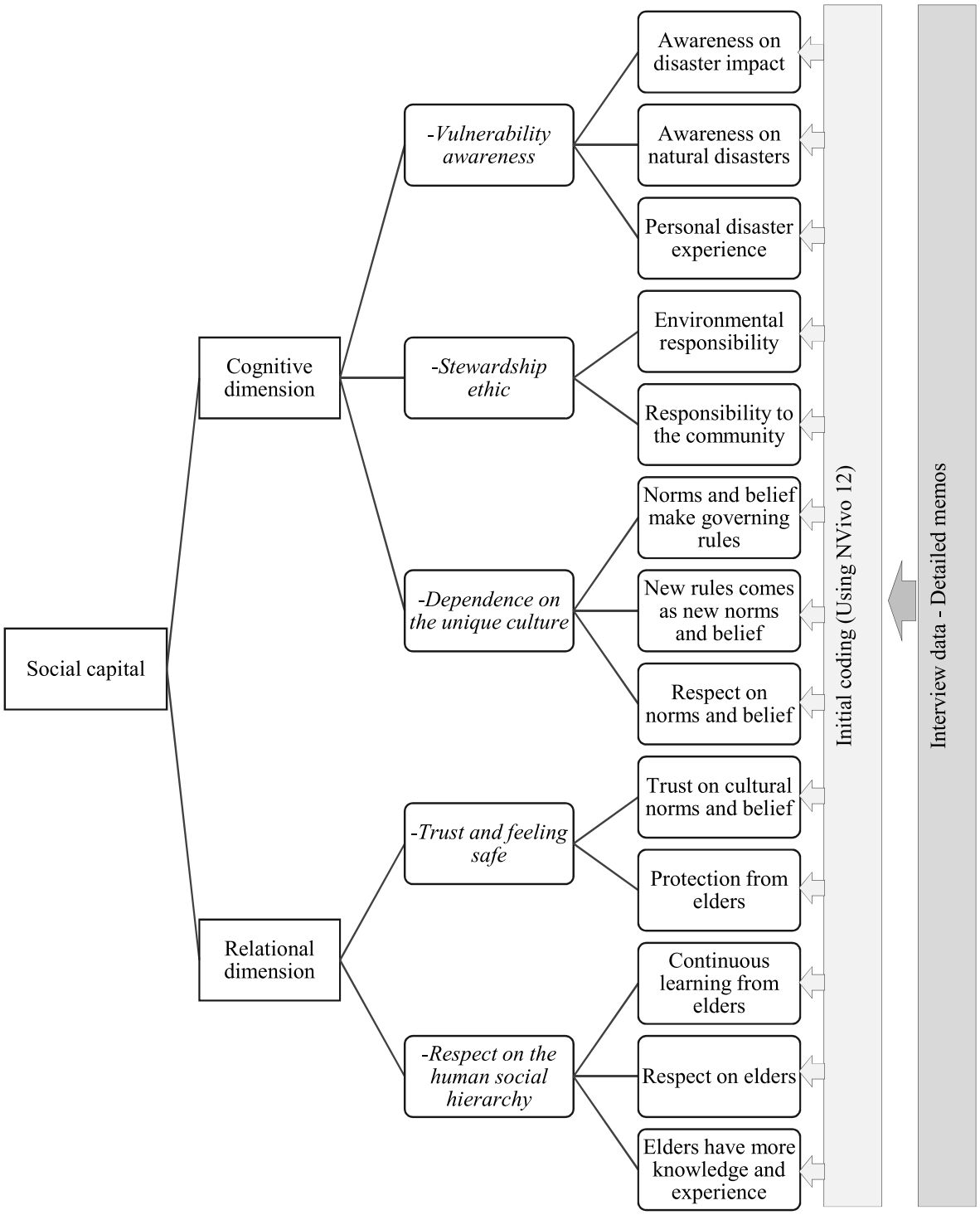


**Fig. 10.** Relationship between codes and themes.

However, elders thought these "hena" happened because they committed sins to the God in this region by clearing the forest. In the past, some called this devastating event as the God who belongs to the region and get angry "Deviyo koopa wela". Therefore, all people believed that if they can stop doing some bad things to the environment, it will help make God happy and protect them from disasters. Therefore, we started believing that clearing this forest makes God angry. Then our elders made a new rule by limiting the forest clearing. They made a forest area preserving for God, and as a result, the person who tried to destroy the forest without permission will get punished. Therefore, after announcing the rule, no one touched the forest which are above their houses. Moreover, it became a strong belief because no landslide happened after this landslide incident, and they all became to respect and are afraid of elders. We never do anything out of elders advice because they guide us and never do anything wrong in front of youngers."

Elders who have lots of experience made them experts in knowledge. The participants respected the elders since childhood, obeyed them, and followed their advice. They learned how to survive and tackle unexpected disaster incidents from their elders (Example 2 & 3). Since the knowledge was derived from experience, elders were experts. Additionally, none of the elders disrespected the younger generations. This emphasized the theme, ***Respect for the human social hierarchy***. Adopting disaster risk reduction measures that were defined by their traditional norms and beliefs made the participants feel safe. Most of the participants felt secured under the protection of an elderly group. According to the story in Example 2, each participant believed in the traditional knowledge of the elders to solve unexpected issues and had confidence in the elders in making decisions based on their experiences for the community. Therefore, they are ***Trusted and feeling safe*** under the supervision of their elders.

**Example 03**. [Mr. B, Case study 01] – "We use "Attam kramaya" working together as a best practice which derived from our ancestors. Our ancestors surveyed by hunting and killing animals. They survived in a team and hunted together as a group. Therefore, the practices of hunting and survival passed from one generation to the next to improve knowledge from elders. The same method is used in doing all our village activities. This practice makes it easy to work as a team as well as to teach younger. Most of the time, I was learning by observing how elders were doing things. Nevertheless, I was got expert while engaging the work with the elders."

Each decision is derived under their advice based on their norms and beliefs. Moreover, the community respects their decisions. Adopting a unique culture based on their norms and beliefs made the participants responsible for protecting the natural environment while engaging in sustainable solutions. Additionally, each individual took responsibility to protect their villages, communities, and cultures make all of them respect in ***Stewardship ethic***.

### *4.3. Uniqueness of social capital in landslide disasters*

According to the categorization of the National Building Research Organization of Sri Lanka, Etanwala and Mandaramnuwara communities lived in areas with a moderate level of landslide risk zone. Furthermore, both the villages were far from the city centers, and more than half of their periphery was covered by forests.

Therefore, the two villages can be considered as geographically isolated communities. With low influence and connection with the outside world, the two communities have sustained their homeland for generations by adapting to landslide disasters. According to the literature, key spatial and non-spatial landslide adaptation measures were identified within these communities [8]. Moreover, the results of this study proved that the communities that adapted to landslide disasters exhibited the same configuration in the knowledge-sharing networks, specifically in landslide disaster knowledge.

According to Figs. 8 and 9, both communities had a highly centralized social network. Within the highly centralized network, approximately three or four individuals were dominant in knowledge-sharing. Both the communities were predominantly agricultural, and the knowledge was received through experiences. Therefore, individuals with more experience were dominant in the networks. Thus, individuals over 60 years of age played a key role in the knowledge-sharing network in both the communities. The younger generation exhibited low centralized scores and the scores increased with age. This trend was observed because disaster knowledge was received through experience. The configurations of both the networks had the same centralized pattern and were unique to these disaster communities.

Considering the cognitive dimensions of the social capital, all communities shared goals and cultures. According to the text coding analysis results, the unit culture and dependence of stewardship ethic were determined as the sets of values within the social capital of the two communities. Therefore, the communities had standard norms and beliefs and their own rules to govern them [46]. Each individual respected the culture. This quality of social capital was observed in both the communities. The relational dimension of social capital referred to trust and beliefs over individuals. According to the analysis, trust and feeling safe were among the other key themes highlighted in the social capital of the network. Therefore, their trust level and respect for their culture and value system was unique to their culture.

Overall, the two communities displayed a unique quality in the social capital of their knowledge-sharing networks. The same configurations, cultural.

Thus, the two communities were unique in social capital based on the above investigated qualities of social capital in a network of local knowledge-sharing of landslide disasters.

### *4.4. Influence of social capital on evolution and transfer of local knowledge in a rural community*

The local knowledge can be explained as tacit knowledge. However, different types of knowledge transfer work together and acquire knowledge by joining and observing the collective actions of knowledge experts. Moreover, the high network centralization and high density of network provide a foundation for local knowledge evolution and transfer in these two communities. Some studies have shown that a central position is used to improve governance for the entire community [68], where centrally positioned farmers are engaged in acquisition, development, and transfer of ecological knowledge to other individuals in their networks [4].

According to the study results, unique pattern and dimensions of social capital in a network can be observed in a rural mountain community that are sustainably adapted to landslide disasters. Highly centralized network patterns support the unique culture, social trust, and unique social relationships, such as respect for human social hierarchy that are conducive for a smooth transfer of local knowledge within the network members. Therefore, the uniqueness and strong qualities of social capital strongly influence the knowledge transfer mechanism. This is the fundamental theory behind the survival of these

communities, which suffer from minor damage during landslide disasters.

The two communities reside in geographically isolated villages in landslide-prone areas of Sri Lanka. Thus, they enhanced their adaptation to major landslide disasters to avoid suffering from severe destruction. According to previous studies, identifying local knowledge-based adaptations for landslide disasters and the influence of social capital in local knowledge-sharing are important considerations, which are often neglected by researchers [18,38,39,46]. Thus, identifying sustainable solutions and mechanisms of knowledge-sharing for landslides is essential.

Sustainable adaptation of communities to landslide disasters facilitates policymakers to engage in disaster risk reduction. Disaster-related knowledge-sharing process within these communities has unique characteristics and is thus a significant factor. Therefore, this unique quality of the social capital of disaster-related local knowledge-sharing network plays a substantial role in transferring knowledge within the groups. Therefore, this unique pattern could be identified in such similarly isolated communities subjected to landslide disasters. Such communities usually do not majorly accept external involvement or inputs. Therefore, the best approach is to transfer new information through the dominant group of the centralized network. The dominant group of knowledge experts will grasp the information and pass the acquired knowledge through knowledge-sharing. This ensures that the entire community receives the knowledge and perceives it positively based on the specific qualities of social capital. Therefore, policymakers and other responsible authorities must understand these qualities included in knowledge-sharing mechanisms and use the centralized networks and qualities of the social capital to share new information or knowledge sustainably.

## 5. Conclusion

Isolated communities adapted to landslide disasters have a unique local knowledge-sharing mechanism. The dimension of social capital of knowledge-sharing network is highly influenced by local knowledge-sharing. Both the communities had highly centralized social network configurations, and their structural dimension was dominated by few community members. These members were knowledge experts who played a key role in knowledge evolution and transfer. Moreover, cognitive and relational dimensions, such as unique culture, social trust, and unique social relationships, including respect for human social hierarchy, facilitated smooth transfer of knowledge within the network members. In particular, these two communities use the locally called "Attam kramaya" (Example 3) method for working as a team in all social and community activity within the village [8]. The same method is used in the case of an emergency as well. Therefore, this is the time that they mostly share their local knowledge and the knowledge related to disaster risk reduction that mainly resided in the elders/experts as tacit form.

In general, the findings indicate how the social capital of a network influences local knowledge transfer and how it is critical in enhancing the resilience of communities to landslide disasters. The two studied communities were self-sufficient and were not well-connected with outside communities, particularly those possessing with landslide risk reduction strategies. The study considers only network ties within the community. The lack of consideration of the outside connections can be a major limitation of this study, and the lessons learned from the case studies shed light on possible future research in investigating the broader range of network ties. This can serve as a key foundation for developing a hybrid approach comprising local knowledge and scientific knowledge to manage the risks associated with landslide disasters.

Local knowledge and the mechanisms of knowledge transfer are the key strengths of these communities to adapt to landslide disasters. Therefore, other case studies should be examined in different landslide disaster contexts. Moreover, a broader range of social ties should be considered to ensure the necessary support from authorized groups to improve the strength of social capital in disaster-prone communities, thereby securing their sustainable survival.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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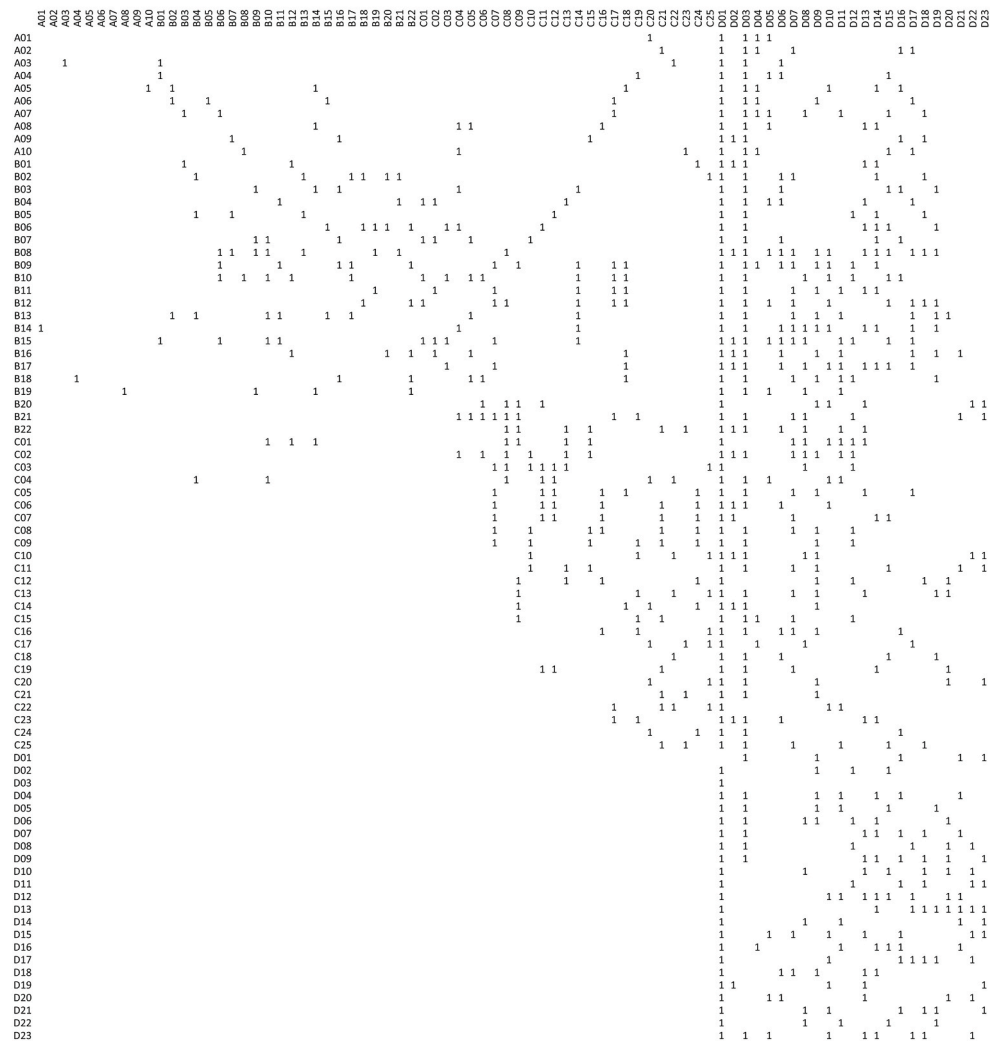
## Appendix 1

Data matrix of the social connections [Case 1- "Etanwala village].

| n | Age category (years) | Code |
|---|---|---|
| 10 | 12–19 | A01~A10 |
| 22 | 20–39 | B01~B22 |
| 25 | 40–59 | C01~C25 |
| 23 | 60- | D01~D23 |



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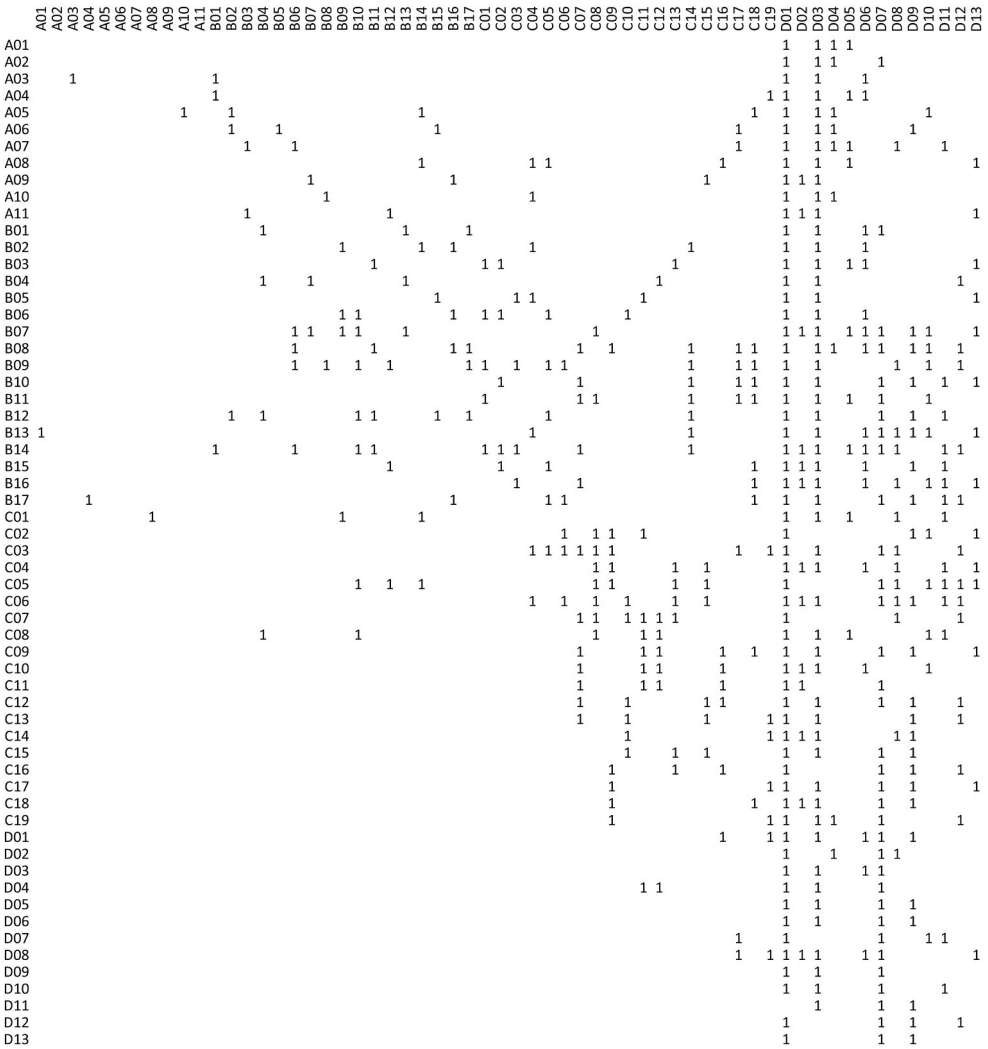
## Appendix 2

Data matrix of the social connections [Case 2- “Mandaramnuwara village].

| n | Age category (years) | Code |
|---|---|---|
| 11 | 16–19 | A01∼A11 |
| 17 | 20–39 | B01∼B17 |
| 19 | 40–59 | C01∼C19 |
| 13 | 60- | D01∼D13 |



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# Consensus of Local Knowledge on landslide Hazard in Depopulated Mountain Communities in Japan − A Case Study on Matsunoyama Village

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**Abstract** Rural depopulation in mountain communities is now well acknowledged as one of the salient challenges faced by Japan which made them more susceptible to landslide disasters with intense weather conditions. The degradation of the traditional culture due to the rapid depopulation in mountainous areas leads to the permanent disappearance of the best local knowledge for landslide disasters. This study attempts to investigate the community's landslide hazard knowledge. The research applied structural questionnaires and informal interviews for data collection. Firstly, the analysis has been conducted for identifying the main components in local knowledge on landslide disasters. Based on the component's results, the questionnaire was developed to measure awareness on those components within the community. Finally, the cultural consensus modelling was utilized in discovering the cultural truths not in individual responses but the degree of sharing of these responses. The research outcomes suggest how the local knowledge-based practices and the consensus of local knowledge had improved the level of disaster adaptation among the community members. Moreover, the findings revealed the impact of depopulation and aging on the sustainability of the mountain community in a landslide disaster environment.

**Keywords:** Landslide, Local Knowledge, Adaptation, Depopulation, Cultural Consensus Modelling

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## 1. INTRODUCTION

Landslides recently became one of the most threatening natural disasters, especially in mountainous areas in Japan. Around 70% of Japan is a mountainous area, and therefore, the country often poses mudslides, landslides, slope failures, and other sediment disasters following heavy rains and earthquakes (Fujita *et al*. 2012; TSUNAKI 2000). In addition to the natural disturbance, social factors such as depopulation and the increased rate of aging in rural areas lead to additional natural vulnerability. The depopulation of rural regions in Japan started from the late 1950s due to the demographic changes and largescale rural-urban migration in post-war Japan (de Oliveira & Paleo 2016; Okubo *et al*. 2016). As the amount of population in rural mountain areas decreases, their inhabitants age rapidly. The rate of the aging population in Japan (people older than 65) became mid-level among developed countries in 1980s. At present, Japan reaches the top among the charts (Feldhoff 2013; Li *et al*. 2021; Tinker 2002). These social issues continuously increase the natural disaster risk specially in mountain communities. Due to this negative trend, the Japanese government established various structural and non-structural actions to prevent disaster risks. Research concerned with landslides and their related impacts has been carried out for more than 50 years. The "Landslide Prevention Law" was established and enacted in 1958 for landslide prevention and mitigation as the first of its kind in the world (TSUNAKI 2002). This law stands as the foundation to improve the technologies for controlling landslide risks in Japan. Since then, landslide investigation methods and several mitigation measures have been developed and continuously advanced (Fujita *et al*. 2012; TSUNAKI 2002).

The strategies and approaches for the preparation of disaster prevention, mitigation, and rehabilitation in developed countries by public or non-governmental agencies are unsuccessful to reduce the vulnerability effectively (Malla *et al*. 2020; Murti & Mathez-Stiefel 2019). The proper establishment and implementation of disaster management need a high degree of adaptability to the local situations. Culture, traditions, and customs play a crucial role in the success or failure of disaster management (Kelman *et al*. 2012). On the other hand, it is necessary to take into account the cultural context in affected localities and areas. In order to develop a suitable user-friendly package, the customs, traditions, local practices, and ethnic compositions in an area should all be considered (Giles *et al*. 2008; Kelman *et al*. 2012; Meyers & Watson 2005). In this situation, there are gaps between the technical information generated from the specialists and the information received from the local communities in the form of risk-based knowledge resulting from the previous disasters and familiarity with the environment, which can be vital for locally appropriated solutions (Fischer 2000). Local knowledge can be defined as beliefs, a set of information, mental abilities, and practices, developed from the adaption practiced through generations by personal interactions (Berkes 1999) and locally "generated through observations of the local environment" (Berkes 2002). It becomes the foundation of all environmental solutions for problems related to agriculture, the health care sector, food preparation, natural resource management, education, *etc* (Berkes 2009; Hiwasaki *et al*. 2014; Islam *et al*. 2018; Lin & Chang 2020). In addition, local knowledge

plays an essential role in contributing the basic techniques and strategies by providing early warning systems and weather forecasting management for disaster risk reduction (Dasanayaka & Matsuda 2019; Hiwasaki *et al*. 2014).

In Japan, the significance of indigenous/local knowledge in disaster risk reduction was emphasized by scholars related to different disaster events during past decades. For example, a story is told and believed to have been handed down by an ancestor who lived in the Sanriku region of Japan, a tsunami-prone area that saved many lives in the Great East Japan Earthquake in March 2011 (Zulfadrim *et al*. 2019). These phenomena describe how local knowledge is vital in disaster risk reduction among communities applying local knowledge to prevent disastrous events. In addition, many researchers have proved local knowledge as a vital factor of community resilience in the process of disaster risk reduction (Aldrich 2011, 2014; Aldrich & Meyer 2015; Mayer 2019; Norris *et al*. 2008). Furthermore, past studies have emphasized the function of local knowledge in disaster recovery (Lippi-Green, 1989) and the need for context-specific cultural understanding of disaster response (Aldrich 2014; Ganapati 2013). Nevertheless, the importance of local knowledge in disaster management was discussed and documented (Ragin & Becker 1992; Zanotti *et al*. 2010), but the effect of the consensus of the landslide-related local knowledge in a depopulating community is still not correctly identified, especially in the population-depleted mountain communities in Japan. Hence, the lack of theoretical research over the critical concepts related to landslide disasters with local knowledge motivated the present research.

Subsequently, this study observes local knowledge in landslide disaster adaptations and investigates whether a shared, local vision of community sustainability and consensus about risk priorities can be identified. This study engages the case study method (Weller 2007) to investigate how the community members identify and take action to risks and how different adaptation decisions are made. This method is suitable to explain complicated problems where research and data are abundant, but the diverse situations is challenging to explain with standalone quantitative analysis. Despite this, Cultural consensus analysis was occupied in finding the cultural answer key in the analysis process. Cultural consensus analysis is a method developed in the 1980s by intellectual anthropologists (Gollin *et al*. 2004). The consensus approach, one of the investigative techniques in cultural domain study, assesses the culturally best responses establishing shared cultural ideas and the informant's reliability in a cultural domain (Nekaris *et al*. 2018). This critical procedure has been frequently applied in ethnobotanical/ecological analyses, for example, to provoke local beliefs of flora and fauna for conservation and management (Carothers *et al*. 2014; Ruzol *et al*. 2021; Van Holt *et al*. 2010). Nevertheless, there is no proper research based on the consensus of local understandings in disaster management by applying cultural consensus analysis (U. Dasanayaka & Matsuda 2022; Morris *et al*. 2010). Therefore, the study described in this paper was focused on uncovering local knowledge through fieldwork with local cultural informants (participants) and relating cultural consensus theory to examine the field data and produce a clear, consistent consensus-based model using cultural consensus analysis for a geologically and culturally important regions of Matsunoyama, Japan.

### 1.1 Local knowledge

Indigenous knowledge/traditional knowledge or local ecological knowledge can sometimes be defined as local knowledge (Traditional Knowledge, n.d.; Wannous & Velasquez 2017). "Traditional knowledge" can be defined as the practices, skills, and knowledge established, maintained, and adapted from generation to generation within a community, commonly forming part of its cultural or spiritual identity (Beilin & Reid 2014). On the other hand, "local knowledge" can be referred to as the knowledge developed by individuals in each community over time and continued to grow. It is developed from repeatedly tested experiences over centuries, adapted to the local culture and natural environment, and embedded in community practices, relationships, and rituals (Hilhorst 2003). Local knowledge is frequently described as distinct from the expert or scientific knowledge, often seen as formalized, explicit, rational, systematized, placeless, non-contextual, and transferable (Lejano & Stokols 2021; McEwen *et al*. 2017). Instead of recognizing the local knowledge as an essential approach to scientific knowledge, the two types of knowledge are often placed against each other and occasionally in normative practices that indicate a point of weakness on the section of local knowledge (Lejano & Stokols 2021).

Moreover, local knowledge is primarily tacit and is often expressed through particular and created stories for better understanding, explanation, and making events in everyday life meaningful (Indian 2007; Leith & Vanclay 2017; Miller *et al*. 2004; Raymond *et al*. 2010; Romney *et al*. 1986). In summary, and for this article, local knowledge refers to the knowledge that individuals in each community have developed over time to reduce the risk embedded in the environment that they live, mainly because of natural disasters like landslides.

### 1.2 Cultural consensus analysis

Cultural consensus theory was established by Romney *et al.* (*Paolisso* 2007) for researchers to analyze the variation among groups and clarify what they term cultural 'truths' and the extent to which these 'truths' are shared in a statistically significant, able, and replicable manner. Cultural consensus analysis is a valuable tool for verifying intracultural difference and agreement patterns in specific areas or domains of knowledge (U. Dasanayaka & Matsuda 2022; Gatewood 2012; Johnson & Griffith 2010; Tokamachi central government office 2005). Cultural consensus theory pursuits cultural truths not in individual responses, although the degree of sharing of these responses by accepting informants' given answers is probabilistic rather than fundamentally true. As a result, it increases the objectivity of ethnographic results, even though these always continue contextually dependent. Romney *et al*. (Paolisso 2007) built a formal mathematical model known as Cultural consensus analysis to achieve this in a replicable approach. Its original method includes planning and administering a survey on a particular cultural domain and subsequent analysis of the degree of sharing of respondent answers. Cultural consensus analysis possesses three key ideas, including that all respondents contribute to a common truth and live within the same cultural life. When appropriately applied, cultural consensus analysis makes us decide whether a cohesive cultural domain exists, the

cultural experience of each respondent, and the culturally 'correct' answer key to the study. Though this practice agrees for an additional organized investigation of a culture generating more strong and generalizable outcomes inside the group under study, the application of cultural consensus analysis results in a list of knowledge and beliefs linked in some unknown means to form a domain of cultural knowledge (Matsunoyama Onsen Tourist Information Center, n.d.).

## 2. MATERIALS AND METHODS

### 2.1 Study area

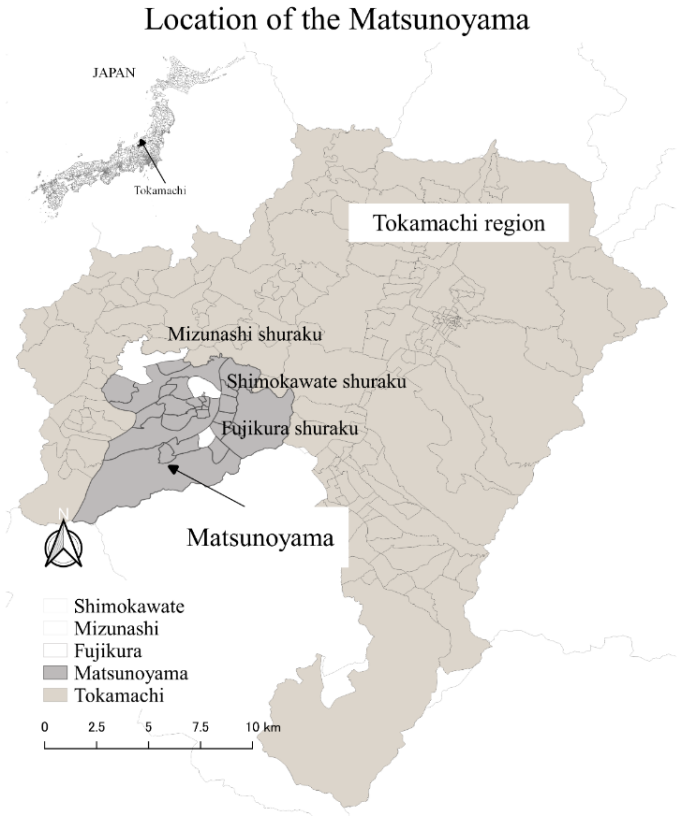


**Figure 1.** Location map of the selected three Shuraku divisions

The study was conducted in and with the community of the one mountain village named Matsunoyama, located in Tokamachi City, in Niigata Prefecture (Figure 1). Matsunoyama was an independent municipality until 2005, then merged into Tokamachi City and another two towns, Kawanishi, Matsudai, including Nakasato village (CITY POPULATION 2015; Matsunoyama Onsen Tourist Information Center, n.d.). The area is known for Tanada/Terrace farming, especially in Niigata Prefecture. Tanada act as the primary landscape attracting tourism, including hot bath 'onsen' (Matsunoyama Onsen Tourist Information Center, n.d.; Nagano 2018). Matsunoyama experienced a 46.4% aging rate from 1975 until 2010, and the population decreased by more than half with 5,930 people in 1975 compared with the 2010 population with 2,542 people (Paris *et al*. 2015). Therefore, decreasing population and a high aging rate can be observed as one of the main challenges Matsunoyama communities face today.

Nevertheless, the area comes under the risk zone of landslide disasters and makes the community more vulnerable to natural disasters, especially landslides. For example, in April 1962, cracks appeared in Usagiguchi, and two years after that, a full extension of 3,600 meters,

an average of 900 meters widths, and a total of around 850 hectares of land of the foot of Matsuyama mountain slipped and moved int northeastern direction toward Koido River. The slip consisted of 7 landslides surrounding Matsunoyama (Figure 2).

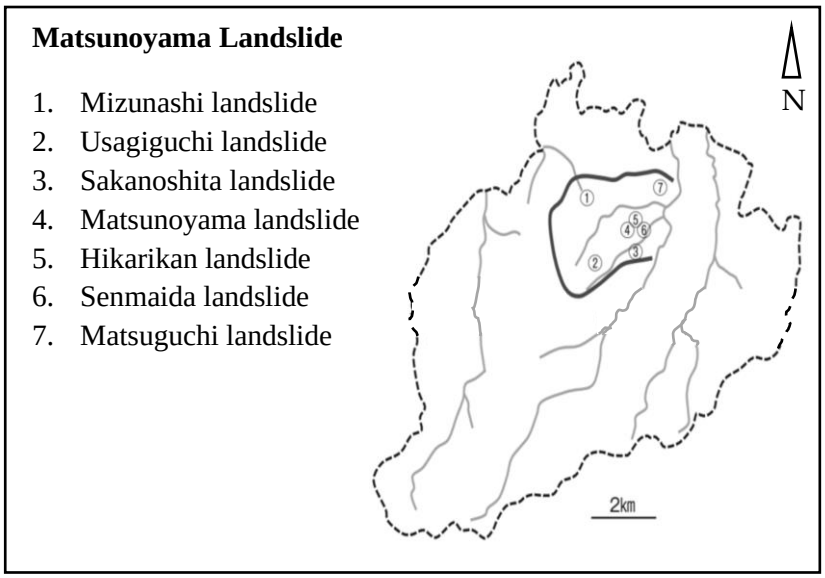


**Figure 2.** Matsunoyama landslide in 1964

As a result, casualties were 349.9 hectares of paddy field, 371 houses, four schools, 15 public facilities, 98 buildings, 5.4 km of prefectural road, and 14.8 km of town road (Koster 2010). Matsunoyama, primarily surrounded by young mountain ranges, possesses steep slopes with unstable geology and a harsh climate to predict. Some areas are incredibly prone to landslides as a result of the meteorological, geographical, and geological conditions and socio-economic characteristics. Therefore, this study selected three communities residing in the Matsunoyama villages with a long history of landslides, located in the shūraku division. Mizunashi Settlement, Shimo Kawate Settlement (Combination of Matsuguchi and Mioke areas), and Fujikura Settlement were selected for this study based on the advice from the Officials in the Tokamachi city office (Figure 1).

Mizunashi is the largest with 4.07 $km^2$, and Shimokawate and Fujikura are 1.40 $km^2$ and 0.70 $km^2$, in area respectively. Depopulation and aging is the primary challenge that these communities are facing. Approximately all three communities had less than 20% elders (above 65 years) in 1975, but in 2020 the elderly population reached almost 50% in all communities (Table 1). Moreover, the total population is 226,222, and 128 in three divisions Mizunashi, Shimo Kawate, and Fujikura, respectively, in 1975. However, the numbers drastically reduced, and in 2020 the population reached 48, 60, and 30, respectively. Therefore, approximately four-fifths of the total population was depleted in all divisions, with only elders existing in the

community (Table 1). The irregularity of the population and the risk of landslide disasters are challenging for these mountain dwellers' sustainable future.

**Table 1.** Key demographic characteristics of three study communities.

| Shūraku | Land area ($km^2$) | Year - 1975 | | | Year - 2020 | | |
|---|---|---|---|---|---|---|---|
| | | Population | Age > 65 | % | Population | Age > 65 | % |
| Mizunashi | 4.07 | 226 | 28 | 12.39% | 48 | 25 | 52.08% |
| Shimokawate | 1.40 | 222 | 37 | 16.67% | 60 | 31 | 51.67% |
| Fujikura | 0.70 | 128 | 18 | 14.06% | 30 | 14 | 46.67% |

### 2.2 Field Data Collection Process and Methods

To gather data on local knowledge on landslide disasters, interviews of the key informants, group discussions, and household surveys were performed in all three village communities. The key informant interviews were done after initial community entry meetings. Based on the data obtained from the preliminary visit and the interviews, a household questionnaire was developed to understand the commonly shared set of local knowledge in landslide disaster risk reduction.

**Figure 3.** Preliminary field visits and meeting with relevant government officials and village leaders.

The number of field visits was made in this study. A preliminary field visit was completed during June and July 2020. The main purpose was to get familiar with the field area and meet with relevant government officials and village leaders (Figure 3). The first field survey was completed from 25th August to 27th August 2020. During the visit, key informant interviews and focus group discussions were done in all three communities. Key informants in this study were made up of the members of traditional knowledge holders recommended by the

government officials and the village leaders who met in the preliminary visits. As a second survey, A household questionnaire was developed and distributed on 6th November 2020. Approximately 51% of questionnaire responses were gathered on 23rd November for further analysis.

### 2.2.1 Key Informant Interviews

After initial community entry meetings in communities, key informants were selected using a convenience sampling approach. Key informant interviews were carried out with five informants, and they were 39 years of age or above and have inhabited in the communities for at least 20 years. Key informant interviews were completed using semi-structured questionnaires (Figure 4). Discussions were focused on local knowledge-based disaster prediction mechanisms and traditional and local disaster coping strategies. In addition, all interviews were recorded in the local language (Japanese) and later translated into English with the help of a professional translator.

**Figure 4.** Preliminary field visits and meeting with relevant government officials and village leaders.

### 2.2.2 Household Questionnaire surveys

A household questionnaires survey was designed to assess the shared knowledge on landslide disaster awareness and the perceived traditional and local disaster prediction and coping mechanisms. Mainly the question was designed based on the local knowledge components identified through the in-depth interviews. The questionnaires were distributed among all the households in all three divisions—twenty in Mizunashi, thirty in Shimokawate, and twelve in Fujikura. However, the research team faced difficulties returning all the distributed survey sheets. The main reason behind this is that the aging population. So many households in those communities remained with very older people; they could not fill questionnaire surveys. However, the research team was finally able to receive a reasonable amount of answer sheets with the help of government officials who work with these communities. Thirty-two questionnaire sheets were received from all three divisions: eight, sixteen, and eight, respectively.

In Matsunoyama region, people mainly have an agriculture-based life system. However, the location is a high elevation mountain region with a high level of risk for landslide disasters triggered by heavy rainfall and earthquakes. Therefore, the community in the mountainous areas with knowledge on landslide disasters were interviewed, and textual analysis was carried out using interview data. The NVivo 12 was used to identify nodes and categories extracted from the discussions. First, all recorded interview data were converted into memos before starting the analysis process. Next, open coding is used to read the information and identify the statements related to the primary categories. Then, Axial coding was used to identify the categories or the components of the local knowledge related to landslide disasters risk reduction. In addition, the second field survey, the questionnaire survey data, was initially analyzed using descriptive statistics to investigate awareness over different local knowledge components. And finally used as an input for cultural consensus analysis to identify the common and culturally consensus set of local knowledge over landslide disaster adaptation.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Textual Analysis

Initially, several components of the local knowledge on landslides were identified based on the in-depth interview answers by running textual analysis (Figure 5). The community defines the landslide using their own terms. The word “Kura” in the local terms is used for small earth slips, and the name “Noge” and “Nuge” are used if the size of the earth slips larger and cannot be corrected by one person. Large landslide called as “Oonoge”. Therefore these communities use **different terms for landslides in their local language**.

Moreover, the community members in the village know where landslides are possible. According to their knowledge, usually, landslides occur in rice fields and abandoned lands. Their village houses are set up on stable ground, not in a place where landslides are likely to occur, from the wisdom of life. Therefore they received proper knowledge of landslide risk areas from their elders and learned by themselves by living in this landslide risk environment. This means they have deep ***knowledge about landslide risks involved in various landuses***. The communities discovered distinct environmental phenomena for use as early indicators for the potential disasters in their living environment. For example, since the three communities in this study had the risk of landslides, they identified different early signs for landslides, such as cracks on the rice fields, movements of animals different from usual, *etc*. Therefore these communities have locally developed methods and **knowledge regarding early signs for landslides**. Rice farming is a part of their life and science past Matsunoyama known for Tanada/Terrace farming, especially in Niigata Prefecture. Most of the terrace lands were abandoned with the depopulation crisis.

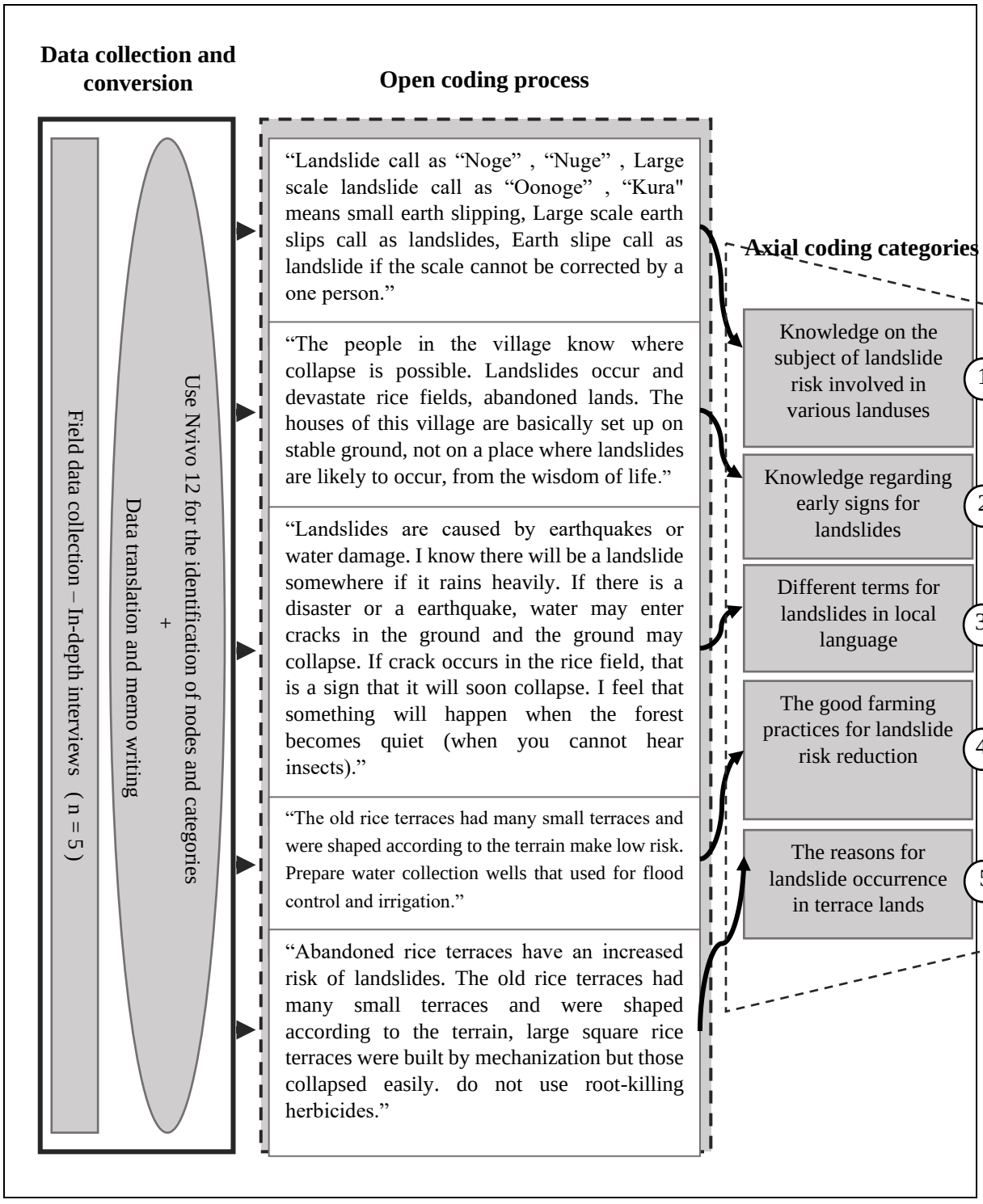


**Figure 5. S**ummary of the local knowledge components extraction process using Text coding.

The area consists of a reasonable amount of rice fields. Accordingly, Mizunashi consists of 0.15 $km^2$, and Shimokawate and Fujikura are 0.17 $km^2$ and 0.06 $km^2$. While engaged in farming in the landslide risk environment, they develop best practices to reduce landslide risk in farmlands. Developing the farmlands without changing the natural shapes of the mountain and

the additional water removal wells are some of their practice methods. This makes it evident that these communities are well aware of ***the good farming practices for landslide risk reduction***. Moreover, the community respects their own techniques for farming, but some individuals try to adopt new technologies to improve productivity. This makes positive insights for the production while some techniques increase the risk for landslides. The use of root-killing herbicides and the reshaping of the terrace steps are the few reasons that they highlighted as ***the reasons for landslide occurrence in terrace lands***.

### 3.2 Level of awareness

The questionnaire survey was designed based on the above key knowledge components and the data acquired during the field observations. The data was initially analyzed using descriptive statistical methods to check the level of awareness of the individuals within the communities (Figure 6). Approximately 80% of the participants had more than 40% awareness of local knowledge on landslide disasters. Five individuals have a level of awareness over 75%. They were in age between 50 to 75 years and resided in the area for more than 40 years. They all have good experiences with farming. The good experience in farming and spending a long period in this area made them well aware of the surrounding environment and respond to the stress from natural disasters like landslides. Out of five, one is female.

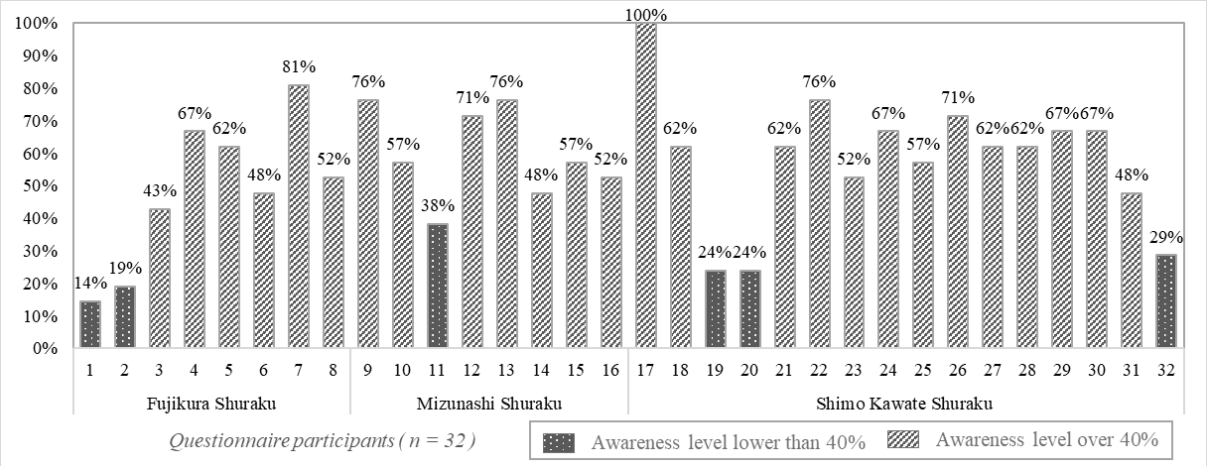


**Figure 6.** Level of awareness on local knowledge relate with landslides

Moreover, the six individuals had awareness lower than 40%. Three of them were over 80 years old females, making it difficult to respond to questionnaires. The other three resided in the area for less than 20 years and have no experience in farming. The person who was over 80 years have a proper knowledge but could not answer correctly, meaning that 3 people from the sample had low awareness over local knowledge. Mainly to have adequate understanding of

local knowledge, need more experience living in the village. Some students who go outside the village for studies may have less awareness of local knowledge. Therefore, according to the survey results, we can conclude that these communities have properly developed local knowledge systems. In summary, the individuals who have more experience farming in the area for an extended period have more knowledge of landslide disaster risk and best practices to reduce the risk.

### 3.3 Cultural consensus analysis

To investigate the survey results and test for cultural consensus, the formal consensus model was utilized, and ran the tests were in UCINET 6 (Garcia *et al*. 2020; Lin & Chang 2020; Oravecz *et al*. 2014). As the resulting output, culture-specific answer key for the survey, cultural competency scores for each respondent, and a first- and second-factor eigenvalues ratio were formed. Respondent answers are weighted based on the respondent's relative cultural competency score to produce the culture-specific answer key. It indicates that the respondents who agree with the majority are weighted more strongly, allowing for a more representative and correct answer key that cultural outsiders do not skew. However, if the ratio of first- and second-factor eigenvalues is greater than three, this answer key can be accepted (Harden 1996). The results show the consensus level over three, which means that the condition is met. Furthermore, all participants as a group indicated a shared cultural model: eigenvalue ratio=4.33 (Table 2), mean cultural competency score of the sample=0.60, SD=0.15, and no negative factor loadings. Therefore results can be concluded that respondents draw from a single, shared knowledge set.

**Table 2.** Summary of the Cultural consensus analysis result

| | |
|---|---|
| Consensus level | 4.33 |
| Largest eigenvalue | 12.33 |
| Second largest eigenvalue | 2.85 |
| Number of negative loading scores | 0 |

According to our cultural consensus analysis (eigenvalue ratio, competence scores), the results show that there does occur an established cultural consensus model indicating culturally framed local knowledge concerning landslide disasters. The cultural consensus model encompasses the techniques and practices used by the participants to reduce the landslide risk in their livelihood. Furthermore, most participants were aware of the different types of land uses, increasing landslide risks. For example, 61.56% and 62.44% of respondents agreed that

the paddy fields and abandoned lands could impose higher landslide risks while residential, terrace, and forest lands have a low risk of sliding (93.19%,1.94%, and 82.03%). Due to the depopulation in the rural communities, the number of farmers decreases. Therefore, most paddy fields are abandoned, and unmaintained paddy fields can create high risks of landslide disaster. However, after the landslide incident, the community identified the risk involved and never used those lands for residential purposes (100%), and 77.59% agreed that they keep those land as abundant. Currently, disaster prediction procedures are valuable and effective with advanced technologies. However, in this approach, the local knowledge concerning the early signs is consistent and valuable for the local community. Four major early signs concerning disaster prediction were identified, which were applied by communities for landslides in this study. The majority of the participants (74.44% and 75.16%) agreed that continuous rainfall and earthquake are the primary triggers for landslides and can be used as early indicators because local inhabitants get cautions for the landslide risks as soon as they notice the heavy continuous rainfall incident for three or four days and the earthquake occurrences (Table 3).

Moreover, unusual earth cracks can be easily detected by checking the recently occurred cracks on the ground; local inhabitants can assume the area has a high potential for landslides. In addition, 58.78% of respondents agreed to use newly appeared muddy water springs as early indicators for landslides (Table 3). As per the interview details, the community used different local terms for landslides like “Kura, Noge, Nuge, and Oonoge”. However, 66.22% of questionnaire participants were agreed that they usually used “Noge” to call landslide. The local term for landslide indicates that it is a part of their livelihood and culture. The community adopted the condition and the risk created from the living environment. Since most individuals engage in full-time or part-time farming, they adopt various best farming practices to avoid landslide risk. For example, building farmlands without changing the shape of the mountain while keeping the size of each terrace field small is one best practice that they have used ever since their ancestors (agreed 63.19%).

Moreover, 68.22% of individuals were mentioned that the proper drainage system for the runoff water could reduce the landslide risk of the farmlands. Some farmers are trying to use new machinery in farming. For example, since the larger paddy fields are easy to work with machinery, the farmers try to reshape the terrace fields without considering the landslide risk involved. 55.91% of individuals emphasize that reshaping the paddy lands is the best practice by considering productivity. The depopulation and aging negatively impact the traditional way of farming. Lack of workers and the existing farmers get old and make them use comfortable methods for farming rather than considering risk factors. In addition, depopulation increases the number of abundant farmlands within the area. Therefore, 82.97% of the participants mentioned that the abundant farmlands course for the landslides occurrences in terrace fields. Other than the above reason, using herbicides and other chemicals can destroy all the grass, plants, and root systems, make the soil loosened, and create earth slides (agreed 70.09%).

**Table 3.** Cultural consensus analysis responses regarding local knowledge on landslides

| Statement | Consensus results | The weighted proportion of respondents who agree with the consensus result (%) |
|---|---|---|
| ***1. Knowledge on the subject of landslide risk involved in various landuses*** | | |
| | | 0% 50% |
| *A. Types of land use which can increase the landslide risks* | | |
| A1. Residential land | Disagree | 93.19 |
| A2. Paddy fields | Agree | 61.56 |
| A3. Terrace lands | Disagree | 91.94 |
| A4. Abandoned lands | Agree | 62.44 |
| A5. Forests | Disagree | 82.03 |
| *B. Best landuse type for landslide occurred land* | | |
| B1. Residential land | Disagree | 100 |
| B2. Paddy fields | Agree | 57.03 |
| B3. Terrace lands | Disagree | 100 |
| B4. Abandoned lands | Agree | 77.59 |
| B5. Landslide prevention work | Agree | 57.78 |
| ***2. Knowledge regarding early signs for landslides*** | | |
| *C. Triggers for the landslide disaster* | | |
| C1. Continuous rain | Agree | 74.44 |
| C2. Earthquake occurrence | Agree | 75.16 |
| *D. Early signs for landslides* | | |
| D1. Cracks in the ground | Agree | 69.53 |
| D2. Tree tilts downwards | Disagree | 65.03 |
| D3. Sounds comes from the tree roots | Disagree | 53.03 |
| D4. Muddy water spring | Agree | 58.78 |
| D5. Movements of animals different from usual | Disagree | 94.34 |
| ***3. Different terms for landslides in local language*** | | |
| *E. Local term for landslides* | | |
| E1. "Noge" | Agree | 66.22 |
| E2. "Nuge" | Disagree | 65.72 |
| ***4. The best farming practices for landslide risk reduction*** | | |
| *F. Best farming practices for landslide risk reduction* | | |
| F1. Building farmlands without changing the shape of the mountain, Keep the shape of each terrace field small | Agree | 63.19 |
| F2. Prepare the fields to be large size to make easier for machinery use. | Agree | 55.91 |
| F3. Built access water removal wells | Disagree | 64.12 |
| F4. Prepare proper drainage system | Agree | 68.22 |
| ***5. The reasons for landslide occurrence in terrace lands*** | | |
| *G. Reasons for landslide occurrence in terrace fields* | | |
| G1. Terrace abandonment | Agree | 82.97 |
| G2. Increasing the size of the terrace steps | Disagree | 69.59 |
| G3. Use of herbicides and other chemicals | Agree | 70.09 |

### 3.4 The consensus of local knowledge on landslide disasters

All three communities in this study live in a mountain village in the landslide-prone area of Japan. Nevertheless, they still improved their adaptation to surviving without experiencing a significant landslides disaster. Local knowledge created on disaster experiences must be individually attained and explained by individuals and the community. The community members should understand to lessen their contact with the threats, which would be a direct and efficient approach to decrease disaster hazards and minimize landslides' impact (Hiwasaki *et al*. 2014). The interview results emphasized that the people living in these mountain villages have proper and well-developed local knowledge over landslide disaster adaptation. The area is primarily agricultural livelihood, and a reasonable amount of land was used for rice farming from the historic period. The individuals who engage in agriculture and have lived in this mountain community for an extended period acquire a sufficient amount of experience. The experience or the exposure to the stress from the natural environment like disasters make them develop their methods to living without disaster risk. However, the level of awareness varied with the level of experience and the exposure; the individuals who lived extended periods while engaged in farming have a high level of awareness over local knowledge on landslides, while individuals who live shorter periods and who did not engage in the farming show a low level of awareness. On average, all the community was well aware of the basics of the exposed disasters and the risk involved. In that context, it is evident from the survey findings that this community has a consensus of the local knowledge on landslide disasters. Once consensus is reached, using local knowledge to address landslide disaster risk prevention might guarantee that the risk prevention measures achieved the community needs (MacDonald *et al*. 2000). All the community members have a consensus over different practices and believe in landslide disaster risk reduction. Further, they adopt unique practices and methods which prevent the probable landslide risks within their communities. The risk involved in different landuses, early indicators for landslide prediction, and best farming practices are the main critical aspects in which they are confident. Therefore, the consensus of the local knowledge on landslide disasters is the one main factor facilitating the sustainable future of these mountain communities. Moreover, depopulation and aging have directly affected the livelihood of these mountain communities. The research findings show that the one main issue is terrace abandonment, and the effect of terrace abandonment is the occurrence of degradation processes such as erosion (Galve *et al*. 2015; Pepe *et al*. 2019; Romero-Calcerrada & Perry 2004). This subsequently leads to an increase in landslide risks (Agnoletti *et al*. 2019; Matanle & Rausch 2011). The community and some researchers found the critical condition facing these mountain communities; the issue remains the same and shows the condition moving to the worse in the future (Agnoletti *et al*. 2019; Pepe *et al*. 2019). This trend will direct a more vulnerable environment for livelihood with the effect of natural disasters like landslides.

In summary, terrace abandonment and the reshaping of terrace lands happen because of the population depletion in these mountain communities. At present, the study three communities in a critical socio-economic condition with the potential risk from the living environment attached with landslide disasters; however, the consensus of the local knowledge on landslide

disaster adaptations makes the condition controlled to some extent. Nevertheless the negative trend subsequently leads to an increase in landslide risks and affects the sustainable future of these mountain communities.

## 4. CONCLUSION

Even though the mountain communities in Japan are depopulated, and in a critical condition, they adapted well to the landslide disaster environment with a unique collection of local and traditional knowledge. The study reveals the unique term for landslide "Noge" emphasizes how much the concept of landslide is embedded in their culture from their ancestors. Furthermore, the research findings indicate how the local knowledge-based practices had enhanced the disaster adaptation level of the community. Knowing the landslide risk involved in different landuses is the key to appropriate landuse planning. However the terrace abandonment and the new farming techniques made the farm land risk in landslides, the community well knowledged in best farming practices to reduce landslide risk. In addition, the community believes different phenomena as early indicators for landslide disasters; the continuous heavy rain and the earthquake as immediate indicators, the earth cracks and muddy springs as other indicators that can be used for landslide prediction.

Furthermore, the consensuses of the local knowledge showed us how well those best practices and beliefs are shared among individuals within villages. Therefore, the all three communities have a consensus of local knowledge, and it is essential for achieving safer livelihood as a unit. However, the transfer of local knowledge is directly affected by depopulation in these mountain communities, which can be leads to the disappearance of valuable local knowledge in the future. In a summary local knowledge and consensuses are key strengths of these communities to adapt to landslide disasters environment. Therefore, the authorities should understand the value of the local knowledge for the sustainability of these mountain communities. Although modern scientific knowledge for disaster risk reduction is vital, it is essential to recognize the role of traditional and local knowledge in enhancing the resilience of local communities, especially in the context of depopulating mountain communities. The research findings initially highlighted the local knowledge in the disaster risk reduction process. Moreover, the findings can act as a key foundation for building a hybrid approach containing local knowledge and scientific knowledge to cope with the risks associated with landslide disasters. As a future study, this research can continue to analyze the impact of the identified local knowledge-based adaptation for landslide disaster risk reduction.

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## CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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