Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction

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Declaration

The work in this thesis is based on the research carried out at the Department of Geography, Durham University, Durham, UK. I confirm that no part of the material presented in this thesis has previously been submitted elsewhere for any other degree or qualification, and it is the sole work of the author unless referenced to the contrary in the text.

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Abstract

Landslides cause substantial human and economic losses globally, notably in lower and middle-income mountainous countries such as Nepal. However, efforts to reduce landslide risks lag behind those for other hazards, with very few successful examples of knowledge integration in landslide risk reduction. This ethnographic study, informed by political ecology and cultural discourses, aims to understand the impacts, risks and vulnerabilities of landslides faced by historically marginalized *'Tamang'* people in Nepal's Sindhupalchok district, the district hardest hit by the 2015 Gorkha earthquake. The study unveils continually evolving local strategies for reducing the risks of frequent small-to-medium scale landslides that are most common and worrying for local people but are often overlooked by 'outsiders' due to their perceived lesser impacts.

My research highlights that people's vulnerabilities to landslides are rooted in systemic marginalization and resource extraction. Even small-to-medium scale landslides cause significant cumulative impacts as compared to larger events. Local inhabitants use diverse and sophisticated knowledges and tactics for reducing landslide risks and impacts. However, such knowledges are dwindling due to continued disregard from decision-makers, outmigration, and the increasing detachment from agriculture-based livelihoods, aggravated by frequent landslides and wildlife incursions on crops.

This study aims to fill key knowledge gaps regarding landslide monitoring and risk reduction. These gaps include the uncertainties inherent in landslide monitoring efforts, often based on rainfall data alone. Additionally, there exists a lack of adequate understanding around the initiation and evolution of landslides originating from less conspicuous areas as well as disparities in how rainfall, sub-surface conditions and slope deformations are perceived. To address these, I use an interdisciplinary approach, combining community observations with instrumental data on rainfall, soil moisture and acoustic emissions signals generated by slope deformation. Findings show the distinct increase in slope deformation during the summer monsoon, signalling the pivotal role of rainfall and progressive infiltration in causing slope instability. This study further demonstrates the use of cost-effective soil moisture and acoustic emission sensors, alongside rainfall, as used in this study, offer potential for continuous monitoring of vulnerable slopes at high temporal resolution, thereby enhancing the reliability of monitoring systems and bridging knowledge disparities pertinent in the field.

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List of abbreviations

3D	Three-dimensional
AE	Acoustic Emission
Av.	Average
BNAC	Britain-Nepal Academic Council
BVAB	Beliefs, Values, Attitudes and Behaviour
Ca.	Circa (A Latin word for around or about)
CBDRM	Community-based Disaster Risk Management
CBDRR	Community-based Disaster Risk Reduction
CBEWS	Community-based Early Warning System
CBLRR	Community-based Landslide Risk Reduction
CCA	Climate Change Adaptation
CCF	Cross-correlation function
CDT	Centre for Doctoral Training
CKM	Co-production of Knowledge Model
cm	Centimetre
CRED	Centre for Research on the Epidemiology of Disasters
DAO	District Administration Office
DCC	District Coordination Committee
DEOC	District Emergency Operation Centre
DHM	Department of Hydrology and Meteorology
DIPECHO	European Commission Humanitarian Aid Department's Disaster Preparedness Programme

DMG	Department of Mines and Geology
DoFSC	Department of Forest and Soil Conservation
DR	Disaster Risk
DRR	Disaster Risk Reduction
DRRM	Disaster Risk Reduction and Management
EM-DAT	Emergency Events Database
EWS	Early Warning System
FGD	Focus Group Discussion
GAA	Geo-Acoustic Aware
GCRF-CDT	Global Challenges Research Fund-Centre for Doctoral Training
GI	Galvanised Iron
GLOF	Glacial Lake Outburst Flood
GPS	Global Positioning System
GSM	Global System for Mobile communication
HCAs	Hazard-Centric Approaches
HDI	Human Development Index
HFA	Hyogo Framework for Action
HVCA	Hazard, Vulnerability and Capacity Assessments
IFRC	International Federation of Red Cross and Red Crescent Societies
IK	Indigenous knowledge
INGOs	International Non-governmental organizations
ISCA	Institute of Social and Cultural Anthropology
LEOC	Local Emergency Operation Centre
LEWS	Landslide Early Warning System

LINK	Local and Indigenous Knowledge
LK	Local Knowledge
Lo-LEWS	Local Landslide Early Warning System
LRN	Local Road Network
LRR	Landslide Risk Reduction
M2M	Machine-to-Machine
m^3/m^3	Cubic meter per Cubic meter
masl	meters above sea level
MoHA	Ministry of Home Affairs
MoHP	Ministry of Health and Population
MoSSaiC	Management of Slopes Stability in Communities
Mw	Moment Magnitude
NA	Not available
NDRRMA	National Disaster Risk Reduction and Management Authority
NEOC	National Emergency Operation Centre
NGO	Non-governmental organizations
NRA	National Reconstruction Authority
NRs	Nepali Rupees
P3DM	Participatory Three-Dimensional Mapping
PAR	Participatory Action Research
PDM	Public Debate Model
PEM	Public Education Model
PhD	Doctor of Philosophy
PPE	Personal Protection Equipment

PRA	Participatory Rural Appraisal
PVC	Polyvinyl chloride
PVCA	Participatory Vulnerability Capacity Assessments
RDC	Ring Down Count
RDT	Rapid Diagnostic Test
RF	Rainfall
RTK	Real-Time Kinematic
SDG	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
SLR	Systematic Literature Review
SMS	Systematic Mapping Studies
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
USD	United States Dollar
VWC	Volumetric Water Content
WHO	World Health Organization

Glossary of Nepali / Tamang words frequently used by participants during fieldwork

(Words specific to Tamang language are noted as ‘T’ in parenthesis)

Aakhe Mam (T)	Great grandmother
Aakhe Mheme (T)	Great grandfather
Aali	Terrace bunds used to manage water availability in the rice fields
Aapa (T)	Father
Airak (T)	Tamang word for home-brewed alcohol
Asare Bikas	A Nepali phrase describing last-minute development interventions overlapping with the onset of monsoon
Barkha	Monsoon/Rainy season
Bari	Dry terrace not suitable for paddy plantation
Bazaar	Marketplace
Bhasinu	Slumping
Bhauju	Sister in-law
Bhel	Flood/Surface run-off laden with some sediment and having high velocity
Bhir	Steep slope
Bhudi boknu	Bulging of terrace walls
Bhukampa	Earthquake
Bhumedevi	The Land goddess
Bhume Puja	Worship of the earth/soil that happens in Jestha (May) and Mangsir (November)—before the cropping and after the harvest of the crops

Bombo (T)	Shaman
Chira parnu	Appearance of crack
Choho (T)	"Head" of "chief" of the village
Daai	Elder brother
Darjyu (T)	Prayer flags
Dashain	A Hindu festival falling in September/October when people worship goddess Durga
Dhanja fatnu	Appearance of cracks on terraces
Dhyangro	A two-sided drum made of deer/goat skin played by shamans in curing sick people and during festivals and auspicious occasions
Didi (di)	Elder sister
Gaai-goru haru	Cows and oxen
Gara	Terrace/Plot
Ghewa (T)	Memorial death feasts held after death of a person
Ghoga	Cob of maize
Goth	Cattle shed
Gothalo garnu	The direct translation is to watch cattle while grazing. However, the term was frequently used to refer to local people monitoring landslide initiation and progression.
Gundri	Straw-made mattress
Jiminko dhani	Territorial deity
Jhakri	Shaman

Jhilap (T)	Holy liquid
Jokhim	Risk/Danger
Kaanla	Terrace walls
Kamere mato	White calcareous soil (Or silty soil)
Khahare	Seasonal (Monsoonal) river
Khani	Term used to refer slate stone mines
Khatara	Risk/danger used synonymously with *Jokhim*
Khet	Wet terrace suitable for paddy plantation
Khola Baulinu	Catastrophic flood causing heavy damage to life and property
Kholsa	Gully
Kira pareko	Infested by bugs
Kuheko chamal	Rotten rice
Kuheko kodo	Rotten millet
Kulo tarkaunu	Cut drainage
Lama	Religious leader
Ledo	Run-off laden with high concentration of sediments/slope materials
Lhosar	Tamang new year based on lunar calendar
Lungtar (T)	Colourful prayer flag with holy verses and images of God put on the courtyard
Makai ko chyakhla	Corn ground
Mam (T)	Grandmother

Mareko bakhra	Dead goats
Mathillo	Upper
Mheme (T)	Grandfather
Mul futnu	Emergence of seasonal water spring
Paharo	Rocky cliff
Pahiro	Landslide
Paklak paklak Janu	Slumping of small masses repetitively at quick intervals
Pakho	Untilled land
Parma	Reciprocal labour exchange practices
Pirka	Flat wooden flank
Purnima	Full moon
Rui (T)	Clans
Sahu	Money lenders
Tallo	Lower
Tamsaling (T)	Tamang ancestral territory
Titepati	Mugwort*; Artemisia sps.*
Tole	Sub-settlement
Yul-lha (T)	Territorial deities/Earth divinities

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Dedication

To my late parents, Mr. Purna Bahadur Shrestha and Mrs. Ujeli Shrestha

and to my wife, Radhika KC and daughter, Tejaswi Shrestha

Chapter 1 Introduction

1.1 Overview

This thesis argues that the landslide risks faced by people in Nepal's rural communities are not solely determined by physical aspects, such as geology and hydrometeorology, but are critically linked with the socio-economic and political context. A series of administrative and socio-political changes have done little to reduce the vulnerability of historically disenfranchised groups such as the Tamangs of my study area. The thesis underscores that the rural populations suffer significant losses from frequent small-to-medium scale landslides yet receive almost negligible attention and support from the authorities, forcing them to deal with these hazards and risk on their own at the expense of their well-being. As such, this thesis is a much-needed attempt to illuminate the stories of endurance and struggles of marginalized populations in dealing with recurrent landslides and other socio-economic hardships that are often invisible to those 'external', including the authorities, media, and development workers.

This thesis also argues that in absence of state's adequate support, marginalized people living in rural communities of Nepal develop and use many forms of knowledge and strategies, derived from inheritance, experience, observation, and intersection with 'external' sources. However, local knowledge and tactics are perhaps increasingly inadequate and are threatened by the combination of various factors such as increased landslide frequency after the 2015 Gorkha earthquake, haphazard rural road construction, changing rainfall patterns, outmigration of workforce, and the erosion of traditional community values and institutions that govern communal hazard management strategies.

Additionally, this study identifies and aims to address key knowledge gaps in the sector of landslide monitoring and risk reduction. Building on the concept of utilizing 'the best of both worlds' (Barahona & Levy, 2007), this thesis also explores ways of synergizing local and scientific knowledges to co-produce socio-culturally informed landslide monitoring systems. For this, rainfall, soil moisture and acoustic emission data, complemented by community observations, are employed. The participatory action research approach with iterative cycles of actions and reflections (Frediani & Nussey, 2021) was followed in knowledge co-generation regarding landslide monitoring. To the best of my knowledge, the use of acoustic emission sensors in landslide monitoring is a novel approach for Nepal. The findings suggest that integrating acoustic emission sensors with other monitoring parameters such as rainfall and soil moisture enable slope monitoring at very high temporal resolution and better reliability. Furthermore, this study highlights the value of participatory monitoring approach employed in this study for bridging the identified knowledge gaps. Finally, this study offers practical insights for future endeavours in landslide monitoring and risk reduction in Nepal and other regions around the world.

1.2 Introduction and background

Landslides are amongst the most impactful hazards across the world and in Nepal in particular, resulting in substantial casualties and economic losses annually (Adhikari & Tian, 2021; Aksha et al., 2018; IFRC, 2023). From 2004 to 2016, landslides caused more than 55,000 fatalities globally (Froude & Petley, 2018). In Nepal, landslides caused annually on average over 100 deaths and economic losses exceeding 1 million USD from 2011 to 2020 and displayed an overall increasing trends in occurrences and associated impacts (KC et al., 2024). The actual impacts of landslides may be much higher due to underreporting or misattribution to primary hazards (for example, an earthquake rather than a co-seismic landslide) (Dahal, 2012; Oven, 2009; Petley, 2012; Petley et al., 2007).

Each year, particularly during the monsoon season, Nepal witnesses multiple landslide events (Froude & Petley, 2018; KC et al., 2024). Some of the recent notable events include the 2014 Jure Landslide in Sindhupalchok District that claimed 156 lives and buried over 100 houses, the 2003 Ramche Landslide in Rasuwa District that took 23 lives, the 2020 Dhorpatan landslide in Baglung District that took 14 lives, and the 2020 Lidi landslide in Sindhupalchok District that killed 37 people (Bhattarai, 2020; Eyler et al., 2022; Rosser et al., 2021; van der Geest, 2018). While these incidents represent infrequent high magnitude events, it is the shallow landslides (<1 m deep) that are most common and cumulatively cause significant impacts on rural livelihoods (Marulanda et al., 2010; Sudmeier-Rieux et al., 2012). However, shallow landslides often receive limited attention from authorities, researchers, media, and policy makers, rendering them as Nepal's 'silent' or 'neglected' disasters (Lewis, 1984; Sudmeier-Rieux et al., 2013; Tønnessen et al., 2002). Consequently, in comparison to hazards such as flooding, the knowledge and practices of risk reduction for landslide are less mature (Basyal, 2021; Oven et al., 2017).

The susceptibility to landslides is tied to multiple physical and anthropogenic factors. For Nepal and the broader Himalayan region, these factors include young steep topography, seismicity, and heavy rainfall, overprinted by human disturbance (Adhikari et al., 2017; Dahal, 2012; Dahal et al., 2008). Researchers suggest that the impacts of landslides in Nepal are likely to escalate due to: i) the ongoing proliferation of poorly engineered roads that destabilize already fragile slopes, ii) roadside migration—both local and far-reaching— in search of new opportunities, exposing people to unfamiliar risks, and iii) the detrimental impacts of climate change on the frequency and magnitude of geo-hazards (Eyler et al., 2022; Fort, 2014; McAdoo et al., 2018; Petley et al., 2007).

Over the last thirty years, there has been a notable expansion of the local road network (LRN) in Nepal, colloquially referred to as '*dozer roads*' due to their generally haphazard mode of construction, often without adequate regulation (Sudmeier-Rieux et al., 2019). LRN coverage grew drastically from 2,662 km in 1995 (Bhandari et al., 2012) to 57,632 km in 2016 (DoLIDAR, 2016), equating to growth of ~2,065% in the past 20 years. With ambitious plans to nearly triple the road connectivity by 2030 compared to 2015 (NPC, 2017; Pradhan, 2021), the three tiers of government -local, provincial and federal- are prioritizing road expansion. However, in most instances, LRNs are not properly engineered, leaving them susceptible to repetitive cycles of failure and clearance, affecting both rural access, adjacent houses, and agricultural land (Robson et al., 2021; Sudmeier-Rieux et al., 2019).

The 7.8 Mw 2015 Gorkha earthquake caused approximately 9,000 fatalities and significant damage to residential buildings and public infrastructure across Central and Western Nepal (MoHA, 2016). Disparities in impact by caste and ethnicity were apparent (CDA, 2020a). With over 35% of the deceased being *'Tamang'* (ibid), some commentators labelled the earthquake as a *'Tamang epicentre'* (Gaha Magar, 2015) or the *'Tamsaling Tragedy'*[1] (Holmberg & March, 2015), highlighting the role of unequal vulnerabilities in producing uneven impacts (Lord &

[1] *Tamsaling* means the ancestral land of Tamang people.

Murton, 2017; Manyena, 2012). Given that a significant portion of the research presented in this thesis involves the Tamang people, I provide a brief background on their historical marginalization in Section 1.2.1 to contextualise their past experiences and their present status.

With more than 3500 fatalities, amounting to over one-third of total deaths, and the complete destruction of approximately 90,000 private houses, Sindhupalchok district, was amongst the worst affected districts in the 2015 Gorkha earthquake (MoHA, 2016). The earthquake triggered around 25,000 new landslides (Roback et al., 2018) with over 20% of landslides occurring in Sindhupalchok (Rosser et al., 2021). The earthquake induced landslides, weakened slopes, and compounded problems on poorly engineered *'dozer'* roads triggered landslides with even low-intensity or amount of rainfall (Karki et al., 2017; Shrestha et al., 2017). This was confirmed by Rosser et al. (2021)'s analysis, which revealed a 39% increase in landslide numbers in Sindhupalchok district post-monsoon in 2019, compared to 2015, suggesting a return to pre-earthquake levels was some way off, even after 4.5 years of the earthquake.

1.2.1 Historically marginalized Tamang people

Victimized for more than two and half centuries of systemic exploitation and exclusion (Ghale, 2015; Tamang, 1992), Tamang people, who live in the hilly areas immediately around the Kathmandu Valley and beyond (Tamang, 2009), are amongst the most marginalized people of Nepal. Beginning from the 17^{th} Century's Gorkha intrusion into Tamang territory, Tamang people had to encounter violent conquest, land and wealth dispossession, extortion of labour and reduction to servitude, especially as porters by the new rulers (Tamang, 2008). The legal code of 1854 called the *Muluki Ain* classified Tamangs as Enslavable Alcohol-Drinkers (masinyā matwāli) meaning they could be legally used as a slave (ibid). The Tamangs were also subject to cultural oppression and humiliation by mainstream Hindu rulers because of their willingness to eat beef, association with Buddhism and cross-cousin marriage (Campbell, 2000; Holmberg, 1989; Kukuczka, 2011). Their situation worsened when King Mahendra introduced the party-less Panchayat system in 1961, enforcing the idea of '*Ek Raja, Ek Desh, Eh Bhasa, Ek Bhesh'* meaning 'One King, One Country, One Language and One Dress' (Hutt, 2019; Whelpton, 2005). Tamang and other indigenous groups were forbidden from speaking their mother tongue and wearing their cultural attire in formal and state contexts (Phyak, 2011). Such years of oppression and discrimination have left the Tamang community economically poor and socio-politically disadvantaged even in the present day (Campbell, 1997; Shyangtan, 2020; Tamang, 1992).

Despite their high vulnerability to disasters like landslides, marginalized groups such as ‘Tamang’ are highly neglected in Disaster Risk Reduction (DRR) research and practice. This research aims to unveil the obscured stories of the vulnerabilities of Tamang people and their strategies for risk reduction in living and dealing with landslides.

1.2.2 Policy and institutional frameworks for landslides risk reduction in Nepal

Following the promulgation of new constitution in 2015, Nepal transformed from the centralized political system to a federal system involving a significant devolution of authority across the three tiers of government -local, provincial and federal- with greater authority delegated to provincial and local levels (Khatri et al., 2022). The 2015 constitution enlisted Disaster Risk Reduction and Management (DRRM) under the sole and shared responsibilities of Federal, Provincial and Local governments (Adhikari & Gautam, 2022; Nepal’s Constitution, 2015).

Consistent with the constitution’s spirit and principles, Nepal ratified the Disaster Risk Reduction and Management Act (DRRM Act) 2017 to replace the response and relief focused Natural Calamity Relief Act 1982 (Natural Calamity Relief Act, 1982; Disaster Risk Reduction and Management Act, 2017; Nepal et al., 2018; UNDRR, 2019). The DRRM Act 2017 paved the way for the establishment of the National Disaster Risk Reduction and Management Authority (NDRRMA), tasked to coordinate and implement DRRM activities across Nepal through line ministries and departments, and provincial and local governments (IOM, 2020; Oxford Policy Management, 2020). Additionally, the DRRM Act stipulated the provision and function of the DRRM National Council and Executive Committee together with the NDRRMA at federal level, the Provincial Disaster Management Committee at province level, and the District and Local Disaster Management Committees at district and local levels (Disaster Risk Reduction and Management Act, 2017). Furthermore, the Nepal Government also endorsed the National Policy on DRRM 2018 (MoHA, 2018b) and the Disaster Risk Reduction National Strategic

Action Plan (2018-2030) (MoHA, 2018a) to align with the international Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030) including short- (2018-2020), medium- (2018-2025) and long-term (2018-2030) priorities for action (MoHA, 2022a).

In addition to the DRRM Act, the Local Government Operation Act (LGOA) of 2017 is key legislation that mandates local government to undertake various functions concerning DRR (Local Government Operation Act, 2017; Oxford Policy Management, 2020). These include the establishment of disaster management committees at local[2] and ward levels, and conducting risk reduction related activities (Local Government Operation Act, 2017). Besides these, sectoral acts and policies such as the Watershed Conservation Act 1982, the Water Induced Disaster Management Policy 2006, the Land Use Act 2019, the Land Use Policy 2015, the Environmental Protection Act 2019 and the National Environmental Policy 2016 are relevant, which all consider aspects of landslide risk reduction and management (Adhikari & Gautam, 2022; Amatya, 2016). Beyond the NDRRMA at federal level and the various tiers of disaster management committees, other ministries, departments, divisional offices, sections, and offices exist at federal, provincial, district and local levels with greater to partial mandates for landslide risk reduction and management (Thapa et al., 2023). Examples include the Department of Mines and Geology (DMG), the Department of Hydrology and Meteorology (DHM), the Department of Forest and Soil Conservation (DoFSC), the National Emergency Operation Centre (NEOC), the District Emergency Operation Centre (DEOC), and the Local Emergency Operation Centre (LEOC) amongst others (Adhikari & Gautam, 2022).

In the backdrop of recent policy and institutional transformations and provisions in Nepal, this study aims to understand how these transformations are influencing the DRR knowledge and strategies of historically marginalized groups such as the 'Tamang'.

1.3 Justification of the study and research questions

The need for the study stems primarily from the existing knowledge gaps and debates in the realm of landslide risk reduction (LRR) in Nepal, and similar mountain developing countries. The knowledge and practice of LRR lags behind other hazards and despite growing calls for

[2] Here local level represents rural municipality and municipality levels.

integration of local and scientific knowledges in DRR efforts (Hadlos et al., 2022), examples of this in LRR are limited (Basyal, 2021; Smith et al., 2022). Further, and in spite of the substantial cumulative socio-economic and environmental impacts of smaller landslide events, these tend to be overshadowed in research, policy and practice compared to larger landslides and other forms of disaster (Bowman, 2022).

This study endeavours to uncover stories of rural residents living alongside landslides and to reveal risk reduction efforts undertaken, focusing on the historically marginalized 'Tamang', as their narratives are often overlooked in DRR discourse (Gaillard, 2022a). The prevalence of landslide incidents post-2015 (Rosser et al., 2021) and haphazard road construction (Carlson, 2019; Sudmeier-Rieux et al., 2019), coupled with the persistent oversight of small-to medium-scale landslide hazards further emphasizes the importance of research on these topics. Furthermore, the contexts of recent and ongoing politico-administrative transformations in Nepal's DRRM sector (as presented in Section 1.2.2 above), heighten the importance and timeliness of this study to understand how people live alongside landslides day to day.

Employing an interdisciplinary approach, this research seeks to better understand the vulnerability context of rural residents in Nepal living alongside landslides, and to explore ways to integrate 'local' and 'scientific' knowledges for better LRR. In doing so, this research seeks to address the following research questions:

1. What factors contribute to the success or failure of existing community-based landslide risk reduction efforts?
2. What are the socio-cultural institutions and processes influencing different knowledges about landslides, and how do these inform strategies for landslide risk reduction?
3. How can scientific and local knowledges be more effectively integrated to develop socio-culturally attuned landslide risk reduction measures in the federal decentralising era of Nepal?

To analyse the reasons for success and failure of those measures (Research Question 1), I have undertaken a systematic literature review that critically reviews studies in both the academic and grey literatures on community-based landslide risk reduction from mountain regions globally. I also undertake an ethnographic study with the Tamang people of Sindhupalchok's Mathillo Sigarche village, which is prone to multiple small-to-medium scale landslides, to explore the various socio-cultural and political processes shaping people's knowledges and strategies for LRR (Research Question 2). Finally, I have worked with my research participants from Mathillo Sigarche and Tallo Sigarche villages in Sindhupalchok district utilizing a Participatory Action Research (PAR) approach (Kindon et al., 2007) to co-produce a socio-culturally informed landslide monitoring system using local people's observation and weather and acoustic emission sensors (Research Question 3).

1.4 Structure of the thesis

The thesis is divided into eight chapters:

Chapter One sets out the context and justification for the study. Here I consider how landslides are amongst the most impactful hazards, yet knowledge and strategies for the reduction of landslide risk are less well developed than it is for other hazards such as flooding. The chapter also offers a brief background on the historical marginalization experienced by my primary research participants, the ethnic *Tamang,* who reside in Nepal's hill districts, along with an overview of the policy and institutional frameworks in Nepal pertinent to landslide risk reduction. Building on my literature review (Chapter Two), this research employs an interdisciplinary approach to better understand the vulnerabilities of people living alongside landslides and explores methods to integrate diverse forms of knowledge in landslide risk reduction to address the research questions set out above.

In Chapter Two, I review the key DRR terminologies and concepts that underpin this research. This chapter sets out how prevailing research, policy and practice can limit the attention paid to high-frequency small-to-medium scale hazards in favour of low-frequency large-scale events, perpetuating a form of 'slow violence' on exposed people. The chapter begins by elucidating key terminologies related to disasters, including disaster, disaster risk, vulnerability, and small-scale disasters. I then consider the evolutionary journey of the DRR sector, transitioning from top-down hazard-centric approaches to the later vulnerability approach, resilience, political ecology, knowledge integration and participatory approaches that are now more widespread in DRR.

Chapter Three outlines the methodological framework and processes adopted to address the overarching aim of this research and three research questions. The chapter begins by describing the study area and the rationale for its selection. I then discuss the fieldwork practicalities such as the research assistant, consent, positionality, and ethical principles guiding this research. The chapter then introduces the data collection and analysis methods and concludes by presenting my reflections on the experience of doing fieldwork during the COVID-19 pandemic. This research involved a systematic literature review (Research Question 1) for analysing the applicability and obstacles to landslide risk reduction measures implemented in different regions of the world (Chapter 4). I then employed a range of ethnographic methods to address second research question about assessing the socio-cultural institutions and processes influencing knowledges and strategies regarding landslides (Chapter 5). Finally, I used a combination of ethnographic and physical science approaches to pilot methods to explore local and scientific knowledges (Research Question 3) in the co-development of socio-culturally attuned landslide monitoring and risk reduction (Chapters 6 – 7).

Chapter Four is based on the systematic review of 39 'self-driven' and 58 'community-based' landslide risk reduction projects. It presents a comprehensive analysis of the applicability and challenges experienced in reducing landslide risk. The distinction between the 'self-driven' and 'community-based' approaches lies primarily in the involvement of external actors or agencies in the latter. This chapter categorizes the studies by year, country of focus and publication source, whether it be book chapters, conference proceedings or journals. Additionally, it groups the array of 'self-driven' and 'community-based' landslide risk reduction measures into categories encompassing hazard, exposure, or vulnerability reduction, response and recovery, risk assessment, risk acceptance and tacit knowledge.

I use the systematic literature review to examine the efficacy of, and challenges encountered through, landslide risk reduction activities. The review emphasizes the imperative for strengthening collaboration with communities, giving greater attention to cultural and socio-economic dimensions, prioritizing 'everyday' concerns and small-scale disasters, and carefully planning exit strategies to achieve better outcomes in community-based landslide risk reduction efforts. This review chapter also advocates for upscaling the community-based landslide risk reduction efforts in countries with low and very low Human Development Index

(HDI) scores. These efforts should involve active engagement of local institutions and researchers for better understanding of local contexts and worldviews.

Chapter Five examines the causes and impacts of 'everyday' landslides for historically marginalized *Tamang* people in Sindhupalchok, a district profoundly impacted by the 2015 Gorkha earthquake. Drawing on ethnographic exploration motivated by a political ecology and cultural perspective, this chapter explores the interplay of bio-physical, socio-economic, and political factors influencing landslide risks as well as people's knowledge and strategies for risk reduction. This chapter sheds light on how disaster vulnerability of marginalized people is deeply entrenched in historical marginalization and resource extraction from the political elites. The research reveals that the small-to-medium landslides, those often overlooked by DRR authorities, researchers, and media, pose significant impacts on local people as compared to the impacts of more large-scale disasters. The research underscores the persistent disregard of people's genuine issues and priorities by DRR governance structures and calls for a significant reconfiguration of resources and decision-making to effectively reduce disaster vulnerabilities of marginalized populations.

In Chapter Six, I highlight the background preparatory works and processes underpinning the Participatory Action Research (PAR) component of my research, specifically aimed at landslide monitoring along two slopes of public concern. This chapter provides a detailed account of key knowledge gaps in landslide monitoring that I later target in the PAR initiative. Chapter Six details the participatory approach followed in identifying those knowledge gaps, and in strategizing and installing landslide monitoring equipment along the two slopes selected in a participatory manner. The chapter also presents the experience of conducting research during the COVID-19 pandemic which had caused significant socio-economic disruption worldwide and in Nepal.

The PAR employed in this research aims to address seven key knowledge gaps. These include a limited understanding of landslides initiating or occurring in areas beyond people's regular interaction but having potential to impact their lives and livelihood, limited knowledge concerning subsurface slope conditions, the lack of precise spatial-temporal specificity and limited accuracy in available weather advisories, inconsistent perceptions of past rainfall and slope instability conditions, the limited examples of slope monitoring that incorporate monitoring of landslide precursors, the scarcity of low-cost landslide risk reduction measures, and a prevalent lack of trust among people in science. The slopes were monitored using people's observational knowledge and scientific instruments to gather data on rainfall, soil moisture, temperature and acoustic emission resulting from slope deformation. Local people and stakeholders were actively involved in shaping the analysis of the collected data for ensuring the resulting information is useful and relevant to their needs and interests.

Chapter Seven presents the analysis of the overall, seasonal, weekly, and daily patterns observed in rainfall, soil moisture and acoustic emissions during the observation period, along with their interrelationships. The objectives of this analysis were informed by the discussions with local residents and other stakeholders. Additionally, this chapter reflects on the important aspects to consider for scaling up or replication of the participatory landslide monitoring in future.

Finally, Chapter Eight synthesizes the findings from chapters 4-7. I begin by drawing key insights gained from the systematic literature review, followed by the reflections derived from ethnographic study around the causes and impacts of small-to-medium scale landslides and diverse local knowledges and strategies used to reduce risks. After this, I reflect on the PAR aspect of this research, specifically focused on landslide monitoring. I then situate the research findings within the realm of contemporary research, policy and practice related to DRR. I question the influence of Eurocentric approaches in DRR research, policy, and practice, stressing the need to address underlying causes of disaster vulnerability, prioritize small-to-medium scale disasters, and integrate local knowledge and meaningful participation. Finally, this chapter outlines the key conclusions, summarizes limitations, and recommends avenues for further exploration.

Chapter 2 Literature Review

2.1 Introduction

This chapter offers an overview of relevant literature pertinent to the overall design and approach taken in my study. The chapter starts by highlighting how the chapter is structured (Section 2.1), followed by the introduction of key terminologies used in the sector of Disaster Risk Reduction (DRR) (Section 2.2). The key terminologies discussed include disaster, disaster risk, vulnerability, and small-scale disasters. Section 2.3 reviews the key conceptual and theoretical frameworks to DRR studies. These include the concepts of pressure and release model of vulnerability (2.3.1), resilience (2.3.2), as well as political ecology (2.3.3), cultural discourse (2.3.4), and participatory approaches to DRR (2.3.5). Within Section 2.3.4, a sub-section on local knowledge (2.3.4.2) has been elaborated to unpack the relevance and approaches of local knowledge in DRR studies and practice. Similarly, within Section 2.3.5, sub-section 2.3.5.1 presents the concept of participatory action research and reviews its application in the sector of DRR.

2.2 Definitions of key terminologies

2.2.1 Disaster

Since the 1940s, social scientists started questioning the 'naturalness' of disasters and began to reconsider disasters as functions of the social and political processes that make people and groups differentially vulnerable to hazards (Bryant & Goodman, 2004; Gould et al., 2016; O'Keefe et al., 1976; Oliver-Smith, 1996, 2016; Wescoat Jr., 2015; White, 1945). Such realization has also begun to be reflected in global policies and commitments related to DRR. For example, UNDRR (2016) defines disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (p.13).

Nevertheless, many researchers critique the contemporary definitions of disaster and the associated policies (see, for example, Wisner, 2020; Gaillard, 2022a). Rigg & Oven (2015) highlight the need to move beyond a 'Ground Zero' approach to hazards for better understanding and addressing disaster risks faced by households and communities. They further underscore that attributing the causations of disasters to natural and supernatural factors overlooks the role of underlying vulnerabilities in creating disaster risks and their impacts. Hence, in academia, there is now a growing call to view disasters not merely as the isolated events but as the "processes that begin long before a hazard's onset and continue long after it subsides" (Faas, 2016a, p. 9).

Often, the 'Western' perspectives of disasters and DRR diverge from those of the local people (IFRC, 2014; Krüger et al., 2015). External entities, including researchers, tend to focus on severe but rare events although most people are more concerned with the smaller events that cause a larger cumulated impacts (Gaillard, 2022a; Shrestha & Gaillard, 2013), or with meeting other everyday needs and risks such as securing livelihood opportunities, or accessing water, health care and other essential facilities (IFRC, 2014). Through the utilization of ethnographic approaches in my research, I seek to comprehend how the indigenous Tamang people understand and interpret disasters and identify what their concerns and priorities are.

2.2.2 Disaster risk

Risk is defined in multiple ways reflecting disciplinary interests. These can be broadly categorised into two dominant themes: a quantitative technical-scientific and a broad socio-cultural perspective of risk (Lupton, 2013; Oven, 2009). Technical-scientific definitions of risk tend to estimate probabilities of events occurring in terms of certain quantitative outcomes such as number of deaths, injuries, houses damaged or economic loss in terms of quantifiable or monetary terms (Hewitt, 1997), whereas socio-cultural definitions emphasize the socio-cultural contexts in which risk is lived, understood and negotiated (Lupton, 2013). Accounting to the interdisciplinary nature of this research, the following conceptual model (Equation 2.1) offered by Blaikie et al. (1994), extended by Wisner et al. (2004) and further expanded in Wisner et al. (2012) has been used for the conceptualization of Disaster Risks (DR) in this research:

$$DR = H \times [(V/C) - M] \quad [2.1]$$

where H stands for hazard, V characterises vulnerability, C indicates capacity for personal protection and M denotes risk mitigation by preventive action and social protection. According to Equation 2.1, disaster risk is the probabilistic function of hazard, exposure, vulnerability and capacity (UNDRR, 2016). Put differently, disaster risk is “a function of the magnitude, potential occurrence, frequency, speed of onset and spatial extent of a potentially harmful natural event or process (the ‘hazard’)” (Wisner et al., 2012, p. 24).

Hazard (H) in the Equation 2.1 can be defined as “a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation” (UNDRR, 2016, p. 18).

Critics argue that framing disaster risks through the lens of risk equation [Equation 2.1] reflects the Western viewpoints that perceives the world through a nature-culture binary, and thereby polarises the hazard and vulnerability studies (Gaillard, 2022a). However, for most people, especially outside the Western context, these aspects are inherently intertwined (ibid). Given the importance of the term “vulnerability” in my research, the term will be elaborated separately in the subsequent sub-section.

2.2.3 Vulnerability

Vulnerability is defined as “the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards” (UNDRR, 2016, p. 24). It represents the degree to which different people in a society are at differential risks of a hazard and have differential capacities to cope with and recover from the hazard (Susman et al., 1983). It may be dependent on different characteristics such as age, race, ethnicity, religion, gender, physical and mental health status, livelihood activities and marital status (Wisner et al., 2012). Wisner et al. (2012) illustrate the various dimensions of vulnerability in the form of a triangle illustrated in Figure 2.1:

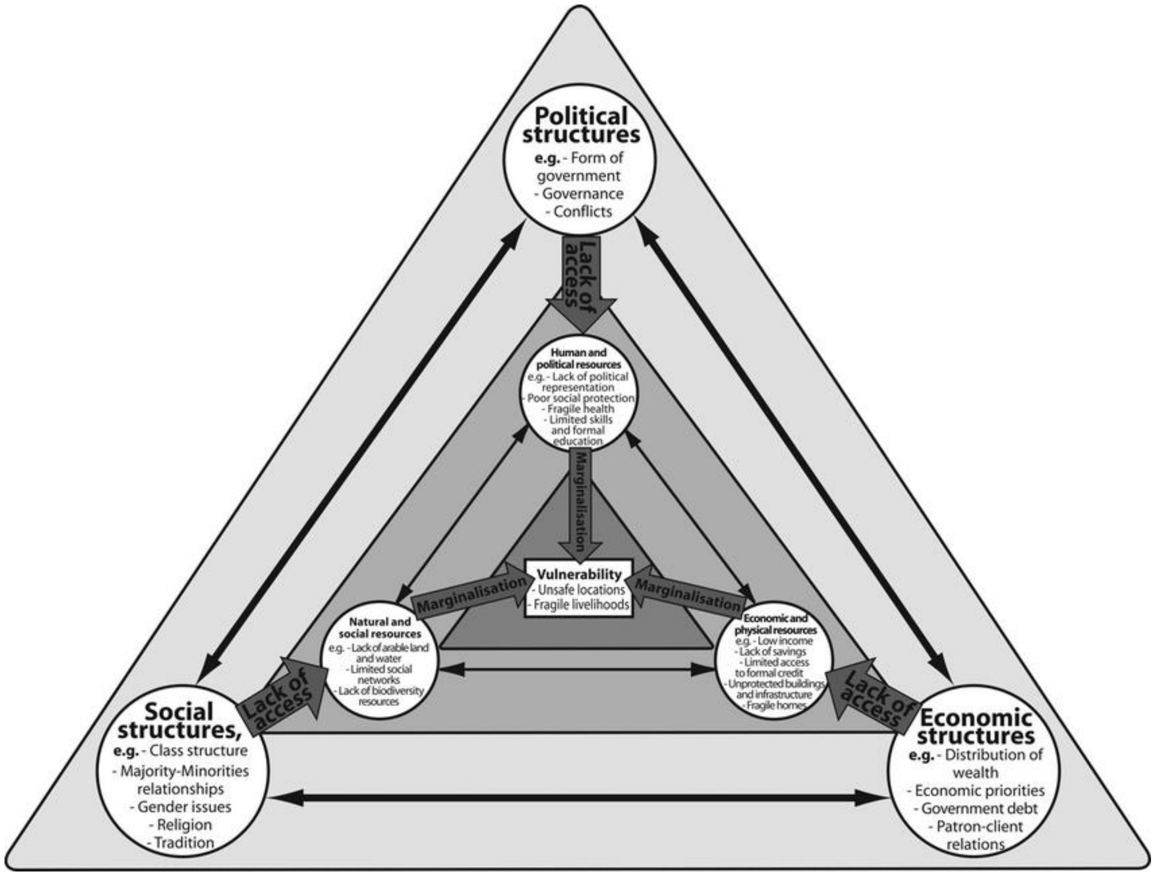

Figure 2.1: Triangle of Vulnerability (Adopted from Wisner et al., 2012, p. 27*)*

As seen in the figure, the mutually interacting political, social, and economic structures in a society shape the degree of people's access to human, political, natural, social, economic and physical resources which ultimately shape people's vulnerabilities within a society. Hence vulnerability is dynamic and varies across time, locations and units (for example, individual, household, community or region) of consideration (de Ruiter & van Loon, 2022). The resources highlighted in the triangle of vulnerability have overlaps with the five 'capitals' of the sustainable livelihoods approach (Ashley & Carney, 1999).

For Cannon (2015), vulnerability has five interlinked components: i) livelihood-strength and resilience, ii) wellbeing, iii) self-protection, iv) social-protection and v) governance-power relations. According to Cannon's framework, the first three components of vulnerability are mainly the characteristics of individuals and households whereas the last two are the organizational characteristics that operate at scales outside the individual and household levels. At first glance, these components of vulnerability seem primarily related to economic and political factors highlighting the role of livelihoods and power systems in determining access to resources and social protection. However, Cannon (2015) further emphasizes that the culture of people and organizations that deal with disaster plays a significant role, alongside the economic and political factors, in influencing the five components of vulnerability.

2.2.4 Small-scale disasters

As highlighted in earlier sections, small-scale disasters are the most common and cumulatively exert substantial impacts on people's lives and livelihoods (Gaillard, 2022a; IFRC, 2014). However, disaster research, policy making, and practice heavily revolve around the large-scale events such as 2004 Asian Tsunami, 2010 Haiti Earthquake and 2015 Nepal Earthquake (Shrestha & Gaillard, 2013). The Emergency Events Database (EM-DAT) which is an international disaster database maintained by the Centre for Research on the Epidemiology of Disasters (CRED) only includes an event as a disaster if it meets at least one of the following conditions (EM-DAT, 2023):

- at least 10 fatalities,
- at least 100 affected people,
- declaration of an emergency state, and
- a call for international assistance.

Unlike such large-scale events that usually have low frequency but higher impacts and meet the criteria for being rendered a disaster, there are many small-to-moderate disasters that have larger frequencies but are often less destructive (Lu et al., 2021; Shrestha, 2016). However, a prolonged exposure to small-to-medium scale disasters can cumulatively cause losses comparable to or even greater than the large-scale events (Ritu, 2020; Shrestha, 2016). Yet, they receive little media interest, public attention and external help because they fail to meet the in-vogue definition and conditions of disaster (Cadag et al., 2017; Wisner & Gaillard, 2009). Such neglect of small- to moderate-scale disasters from scientists, policy makers and practitioners (IFRC, 2006) render them 'hidden' or 'invisible' (Cadag et al., 2017; Wisner & Gaillard, 2009).

EM-DAT's criteria and database characterizes how the global and national databases on disaster undermine the small-to medium-scale events (Froude & Petley, 2018). Databases that neglect the smaller events fail to give the accurate picture of human, social and economic impacts of disasters (Johansson, 2015; Marulanda et al., 2010). A problematic implication could be that the global and national reports and policy frameworks (see, for example, IFRC, 2023) prepared considering databases like EM-DAT might result in the inaccurate impression of disaster hotspots and resource gaps in the global, national and local contexts. Consequently, this phenomenon resembles a state of 'strategic ignorance' (Huber, 2019; Mcgoey, 2012), that exacerbates the institutional neglect towards marginalized people in terms of policy responses, forcing the vulnerable populations deal with such events on their own (Cadag et al., 2017).

The disaster risk reduction, response and recovery policies and plans formulated neglecting small- and moderate- scale disasters significantly diminish the effectiveness of such policies and plans in addressing the issues and challenges of many vulnerable populations prone to or impacted by such events (IFRC, 2006; Shrestha & Gaillard, 2013). Often, the people affected by small-scale disasters come from the most marginalized segments of society (Wisner & Gaillard, 2009). Because of their frequent nature, the households and communities that face small-scale disaster may be impacted by a subsequent disaster before the recovery from earlier disaster is completed (Tennakoon et al., 2023). The neglect of small-scale disasters can create a vicious cycle of marginalization and vulnerability (ibid). Such condition is comparable to what Nixon (2011) refers to as 'slow violence' in his book *Slow Violence and the Environmentalism of the Poor*. Addressing this issue necessitates the collaborative efforts from scientific and local communities over extended duration to unfold the widespread but elusive stories of incremental precarity caused by the small and moderate disasters over time, as well as of the power dynamics contributing to uneven impacts and vulnerabilities (Davies, 2022).

2.3 Theories and concepts of disaster risk reduction

2.3.1 Vulnerability approach to understanding disaster risk

Amongst the several theories on vulnerability and Disaster Risk Reduction (DRR), the pressure and release model (see Figure 2.2) developed by Blaikie et al. (1994) and advanced by Wisner et al. (2004, 2012) is a highly cited model. It explains disasters as the outcome of the intersection of two distinct processes: the physical exposure to hazards and the socio-cultural processes generating vulnerability.

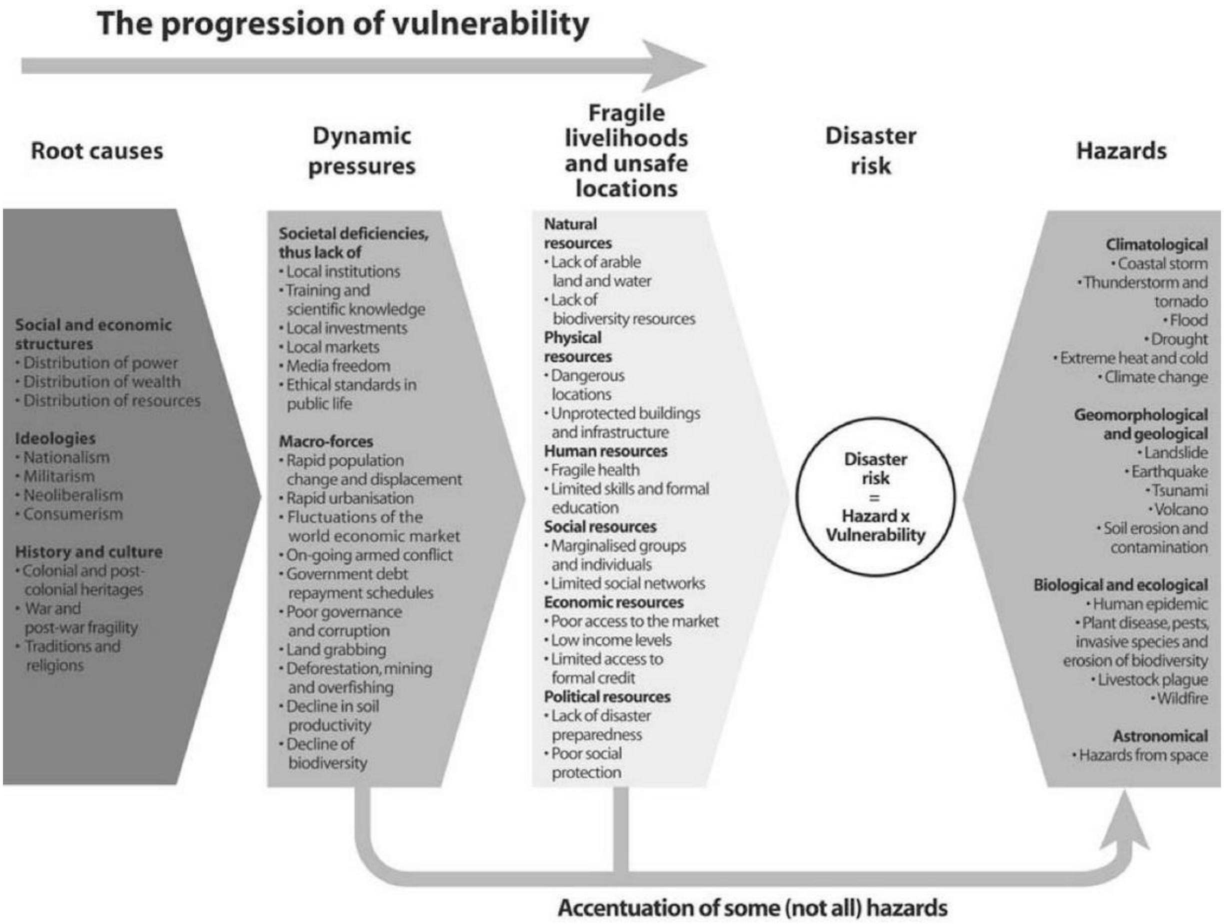

Figure 2.2: The progression of Vulnerability (Pressure and Release model) (Adopted from Wisner et al., 2012, p. 23)

Wisner et al. (2004, 2012)'s model does not deny the existence of natural hazards but importantly highlights the three distinct stages of progression of vulnerability: root causes, dynamic pressures, and unsafe conditions. It explains how the root causes such as socio-economic structures, ideologies, history and culture shape the dynamic pressures such as deforestation, rapid population growth, land grabbing, poor governance and corruption, and lack of institutions providing services in society. This eventually increases disaster risks by manifesting precarious livelihoods and unsafe conditions such as fragile physical environments and local economies, inadequate social protection and exposed buildings and groups. Hence, it is important to execute measures addressing different levels of vulnerability progression alongside the measures targeting hazards for releasing pressure and ensuring effective DRR (Wisner et al., 2004, 2012). However, most DRR interventions promote hazards-centric approaches (HCAs) rather than improving access to resources (Li, 2016; Oven et al., 2019). Such top-down HCAs rely on 'outside' knowledge and resources rather than the local knowledge and resources, undermine the communities' role and participation, and do little to restructure the power and resource asymmetries within the community (Maskrey, 2011). As a result, such approaches are comparable to merely treating the symptoms rather than the underlying root causes, and are insufficient in achieving longer-term outcomes in DRR (Clerveaux et al., 2010; Oliver-Smith, 1996).

2.3.2 The concept of resilience in disaster risk reduction studies

The term *'Resilience'* is originated from the Latin word '*Resilo'* that means 'to jump back' (Klein et al., 2003). The field where this term was first used is debated but at present it is widely applied in multiple fields including DRR (Brown, 2014, 2016; Manyena, 2006). In recent years, the concept of resilience features prominently in academic, policy and public discourses and debates at all levels from global and national to local levels (Leach, 2008; Rigg & Oven, 2015). In literature and practice, resilience has been understood both as a desired outcome as well as the process leading to that outcome (Rigg & Oven, 2015; Twigg, 2015). UNDRR (2016) defines resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (p. 22). Critics consider such definition of 'resilience' as ambiguous because what is necessary to resist a hazard may be quite different from what is needed to adapt, transform, or recover (Béné et al., 2012).

There are several ways in which the term 'resilience' has been defined and used (see, for example, Brown, 2016; Manyena, 2006; Miller et al., 2010). A key criticism for most definitions and approaches of 'resilience' is its failure to sufficiently account for power and resource asymmetries (Deeming et al., 2019). Katrina Brown (2016) in her book entitled *Resilience, Development and Global Change* argues that resilience thinking is vague and emphasizes technical solutions over the socio-political mechanisms that underpin the foundations of vulnerabilities for many. Quite often, a 'resilience' lens results in the devolution of the responsibility for DRR primarily on local people, thereby reinforcing pre-existing power relations (Nightingale, 2015; Tierney, 2015). Hence, for resilience to become a useful decision-making tool, it should aim to address the root causes of risk and vulnerabilities (Gaillard, 2010; Sudmeier et al., 2013).

In the DRR sector, researchers and practitioners connect resilience and vulnerability in diverse ways: some consider resilience as the opposite of vulnerability (Bahadur et al., 2010; Folke, 2006; Klein et al., 2003; Twigg, 2009) while for others although there could be some overlaps, they are not opposite to each other (Gallopín, 2006; Timmerman, 1981; Twigg, 2015). Turner et al. (2003) consider resilience, exposure and sensitivity as the three dimensions of vulnerability allowing a community to become resilient and vulnerable at the same time if the exposure and sensitivity are also high (Brown, 2016). Likewise, there are also many researchers with the opinion that the two terms and concepts are distinctly separate (Manyena, 2006).

Advocates of resilience as an approach to DRR efforts consider that the systemic focus of the concept acknowledges the wider processes and dynamics influencing people and their environments across multiple scales (local to global) (Béné et al., 2012). They tend to criticize the vulnerability paradigm for placing emphasis on people's weaknesses in comparison to their intrinsic capacities (Gaillard, 2022a). The proponents of 'resilience' thinking believe 'resilience' as a 'bouncing forward' concept which leads to activities that enhance community coping capacity and livelihoods (Manyena et al., 2011; Sudmeier et al., 2013). Yet, critics consider that such emphasis on enhancing capacities might negate the attention necessary to address the root causes of vulnerabilities (Gaillard, 2010; Tamang, 2015). Critics also consider the term 'resilience' to be vague, with the concept assuming significantly different meanings in different contexts (Nightingale, 2015).

Labelling people as 'resilient' risks the perception that people can and will manage disaster risks or other troubles on their own (IFRC, 2016). Hence, 'resilience' is not 'pro poor' (Béné et al., 2012) and might be achieved at the cost of wellbeing (Armitage et al., 2012). The excessive romance with 'resilience' might push towards bio-physical explanation of shocks and stresses from natural hazards (ibid) and eventually lead to the justification for doing nothing or endorsing technical solutions without challenging underlying power asymmetries (Levine et al., 2012; Tamang, 2015).

Despite disputes about meanings and application, debates on resilience have the potential for creating space for discussion and enriching the scholarship (Alexander, 2013; Brown, 2014). To make the 'resilience' paradigm more useful for vulnerable people, resilience building should focus more on understanding and addressing the root causes of risk and vulnerabilities (Béné et al., 2012; Levine et al., 2012; Sudmeier et al., 2013). Government and other actors having access to resources and the mandate to address people's vulnerabilities should be made accountable to address the situation adequately and effectively (Manyena, 2006; Ruszczyk, 2017). Resilience building efforts should also aim to reduce poverty and improve the wellbeing of people (Lavers, 2007). In a nutshell, resilience building interventions should aim to bring positive, equitable and proactive change in the complex and dynamic socio-ecological systems (Brown, 2016).

2.3.3 Political ecology of risks, hazards, and vulnerabilities

Approximately 80 years ago, the social scientists began exploring the 'non-natural' and 'non-divine' dimensions and explanations of ecological crises (Wescoat Jr., 2015; White, 1945). In the 1970s, a movement emerged, emphasizing the influence of social inequalities, political and economic factors on risks in everyday life and the capacities to cope with loss, which is broadly referred to as political ecology (Aboagye, 2012; Oliver-Smith, 2016; Wolf, 1972). Political ecology incorporates the interrogation of power and politics, winners and losers, plural perspectives and narratives, rights, access and justice to understandings of environmental problems, and encourages people to question the framings and explanations behind any ecological issues and their solutions (Brown, 2016).

Most physical scientists consider disasters as the result of geophysical extremes such as storms, earthquakes, avalanches, droughts, etc. and attempt to address the environmental problems using science and technology, but political ecologists argue that it is the social, political, and economic relations that generate the differential disaster risks (Faas, 2016b; Oliver-Smith, 1996; Toledo & Aravena, 2015; Wisner et al., 2004). The use of political ecology approaches in disaster studies has unveiled many diverse aspects of disasters. For instance, Leach (2015) and Wilkinson & Leach (2014) interpreted how the 2013/14 Ebola Crisis in West Africa emerged and worsened from the assemblage of long-term structural, socio-economic, technical, discursive, and political exclusions and injustices. Maes et al. (2019) analysed how overlooking the socio-political aspects of disasters such as poor enforcement of risk zonation policy and corruption in Cameroon's Limbe city over the bio-physical aspects led to disaster risk accumulation rather than reduction.

Similarly, Pelling (1999), in his research about flood hazard in urban and peri-urban Georgetown of Guyana, showed that 'community sponsored development' projects, funded by international donor agencies, ended-up benefitting the interests of local and national political and economic elites more than the most vulnerable communities. Austin & Mejia (2019) highlighted how the expansion of coffee gardens in rural Uganda for coffee export to the Global North increased the incidents of landslides and associated environmental and human costs compounded by deforestation, soil erosion and excessive fertilizer use. Likewise, Baruah (2023) and Gladfelter (2022) highlighted how the focus on techno-engineering solutions to flood hazards, such as the construction of embankments and levees, in India's Brahmaputra Valley and Nepal's Karnali River basin respectively, served to reproduce people's differential access and vulnerabilities. Similarly, while Donner (2007) employed the POET (Population, Organization, Environment and Technology) model to assess the role of demographic and social factors in vulnerability to tornadoes in the United States of America, Collins (2008) used the concept of marginalization and facilitation to demonstrate how the shift from resource extraction to an environmental amenity-oriented economy in Arizona's White Mountains disproportionately diminished the livelihood security and escalated wildfire risks for working class people.

In summary, a political ecology approach encourages us to explore the interlinked explanations of vulnerability causations and hazard impacts (Brown, 2016), thereby enhancing precise understanding of issues related to risk, vulnerability, mitigation, and resilience (Wescoat Jr., 2015). However, the political ecology model is not free from criticisms. Often, it is critiqued for being either insufficiently political or ecological (Faas, 2016b; Forsyth, 2008; Lave, 2015a, 2015b; Walker, 2005; Wisner et al., 2004). Consequently, attempts to maintain a balance between politics and ecology in geography led to the emergence of a new field called *critical physical geography* (Lave et al., 2014). Nevertheless, critical physical geography has deep roots in political ecology (Lave et al., 2018), and "combines critical attention to relations of social power with deep knowledge of biophysical science or technology in the service of social and environmental transformation" (Lave et al., 2014, p. 7).

Critical physical geography recognises that "we cannot rely on explanations grounded in physical or critical human geography alone because socio-biophysical landscapes are as much the product of unequal power relations, histories of colonialism and exploitation, and racial and gender disparities as they are of hydrology, ecology, and climate change" (Lave, 2015b, p. 571; Lave et al., 2014, p. 3). Such an approach has been successfully used in flood risk management in Pickering, North Yorkshire, UK (Lane *et al.,* 2011), and for knowledge co-production about farm slurry pollution in the Lune River Catchment in the UK (Whitman et al., 2015). Importantly both studies are UK based—representing the developed world context and focused on relatively straightforward hazards: floods and pollution. Critical physical geographical studies about hazards in developing world contexts are limited, with a great deal of potential. In my research, I therefore employ a political ecology approach, informed by the insights from critical physical geography, to understand both biophysical and socio-cultural processes that shape landslide vulnerabilities and risks, and explore ways to effectively manage landslide hazards, vulnerabilities, and risk by bringing together scientific and local knowledge in a more culturally appropriate manner.

2.3.4 Cultural discourse in disaster risk reduction research and practice

Culture is defined in multiple ways within the academic and development literature. The IFRC (2014) defines culture as the wider processes by which societies operate; and culture in relation to risk is described as "the ways that people interpret and live with risk, and how their perceptions, attitudes, and behaviour influence their vulnerability to hazards" (p. 14). Culture is neither static (Warner & Engel, 2014; Wright, 1998) nor something that we find 'on the ground' (Ingold, 1994). It is "fluid, evolving, and intertwined with a host of constantly altering economic, political, and social relations and tensions" (Maldonado, 2016, p. 53).

Research on culture and disaster has explored the role of culture in shaping disaster risk and DRR in at least seven different ways: i) culture in the form of beliefs and perceptions of risks (see, for example, Ayeb-Karlsson et al., 2019); ii) culture in the form of rituals having direct or indirect linkage with disasters (see, for example, Butcher, 2017); iii) culture as the role of kinship, sense of place, social networks and moral values of people to help each other and people in need (see, for example, Carrero et al., 2018; Khattri, 2021); iv) culture as the indigenous knowledge—both tacit and explicit—used to reduce disaster risks and manage disasters including in anticipating disasters (see, for example, Dekens, 2007; Jha & Jha, 2011; Sanford et al., 2020); v) culture in the form of people's priorities and rationalities to live with risks (see, for example, Oven et al., 2021); vi) culture in the form of caste status, gender roles and other power relations that affect vulnerability and access to resources (see, for example, Bownas & Bishokarma, 2019); and vii) culture as a material and non-material component prone to and affected by disaster (see, for example, Simpson, 2005; Suri, 2018 and section 2.3.4.1).

Religious belief plays a crucial role in shaping perceptions and actions in relation to disaster risks (IFRC, 2014; Purworini et al., 2020). Butcher (2017), in her ethnographic study conducted in Ladakh of India, highlighted that many people, particularly the influential spiritual leaders, attributed disasters like floods and earthquakes to god's anger, viewing the hazards as punishments for decline in moral behaviour. However, the literature suggests that religious explanations are often found in tandem with non-religious explanations and responses to disaster risk (see, for example, Chakraborty & Sherpa, 2021; Sherry et al., 2018). Drawing on ideas from Pigg (1996) in the context of traditional and modern medicine, Oven (2009) stated that her research informants from the Upper Bhote Koshi Valley of Nepal did not possess blind faith in supernatural phenomenon. Instead, most were commonly engaged in both religious and non-religious interpretations of and actions to manage landslide risks, highlighting knowledge plurality.

Within various cultural contexts, rituals and religious ceremonies are considered as significant factors that can directly or indirectly influence disaster risks and their impacts (Suri, 2018). Butcher (2015, 2017) highlighted the perceived importance of performing rituals, such as offering smoke of burnt juniper to local deities, in preventing the devastation of disasters like floods and earthquakes in Ladakh, situated in the Himalayan region of India. Oven (2009)'s research respondents in Central Nepal, who primarily followed Hinduism or Buddhism, emphasized the importance of praying gods for regularizing climate, sustaining afforestation, preventing landslides, and prolonging the lives of check-dams that they construct to mitigate landslide impacts. In addition to the ritualistic offerings and prayers, Campbell (2013b, 2020), through his extensive ethnographic engagement with communities in the Nepalese Himalayas, revealed that people prioritize adhering to moral and religious behaviours, such as showing reverence to sacred sites and performing regular religious offerings to deities, to prevent the impacts of disasters like hailstorms and landslides, including other adversities like crop failure or diseases among family members.

Furthermore, other researchers have adopted a cultural approach to investigate disaster risks and impacts in relation to kinship and social networks (see, for example, Carrero et al., 2018; Sun et al., 2018); indigenous or local knowledge (see, for example, Dar & Ahmad, 2015; Jha & Jha, 2011; Kelman et al., 2012; Kulatunga, 2010; Šakić Trogrlić et al., 2019); people's differential priorities and rationalities to deal or live with risks (see, for example, Ayeb-Karlsson et al., 2019; Oven & Rigg, 2015; Ritu, 2020); and the role of caste, gender and other power relations (see, for example, Gaha Magar, 2015; Sudmeier-Rieux et al., 2012). Given the focus of my research on exploring the local knowledges and strategies, *Section 2.3.4.2* will delve deeper into the literature on local knowledge in DRR.

Drawing from the examples and discussions provided above, it is apparent that cultural factors are crucial in influencing people's perception of, and the actions taken to reduce, disaster risks. In her collection of essays entitled *Risk and Blame* (Douglas, 1992), Mary Douglas delineates four broad categories that encapsulate the diverse perception and cultural responses to risks: i) fatalistic, ii) egalitarian, iii) hierarchical, and iv) individualistic. Those adopting a 'fatalistic' stance believe in the inherent unpredictability of nature and perceive that there are only limited things that can be done to control it. 'Egalitarian' individuals approach risks from a moral perspective, and advocate for a holistic and equitable approach to alleviate disruptions in nature and address social inequalities. The people with 'hierarchical' perspectives emphasize the significance of hierarchy in formal and informal governance systems in managing the disaster risks within a community. On the other hand, those with 'individualistic' perspectives consider risk management to be a personal responsibility (ibid).

2.3.4.1 Culture as a material and non-material component prone to and affected by disaster

Cultural factors not only contribute to the shaping of disaster risks and risk reduction measures, as discussed above, but are also shaped by disasters themselves. For instance, Sharma et al. (2018) highlight how the building models recommended by the Nepalese Government in the aftermath of 2015 Gorkha earthquake overlooked the traditional building design and housing space requirements. Yet, to be eligible to access housing reconstruction grants and due to cost implications, people were compelled to construct the government-approved designs that were smaller and different in appearance than traditional houses (Limbu et al., 2019). Thus, Nepal's 2015 earthquake reconstruction experience shows how disasters and state-led policies related to DRR, recovery, and reconstruction could lead to the transformations in tangible aspects of culture, as evidenced by the shift in traditional housing architecture in the context of post-earthquake reconstruction in Nepal.

Transformations in traditional architecture after a disaster have been observed elsewhere. For example, Dar & Ahmad (2015) highlight how the traditional *taq* (timber-laced masonry) and *dhajji dewari* (timber frame with masonry infill) structures in the Kashmir region of India and Pakistan, were replaced by concrete buildings after the 2005 earthquake, often resulting in increased risks compared to the traditional designs and infrastructures. Similarly, analysing the impacts of multiple disasters like flash-floods, landslides and cloudbursts in Ladakh, Suri (2018) argues that disasters can impact both tangible and intangible cultures in the form of damage to monasteries and mosques, and a decline in celebration of festivals, ceremonies, and rituals, and the wearing of traditional dress. Likewise, Campbell (2017) highlights how the failure of wheat fields due to insufficient winter rain posed challenges for the Nepal's Tamang community in celebrating the local festival called *chang phit*, during which Tamang people traditionally offer some of their new harvest of wheat to their clan god before consumption. Simpson (2005), in the context of the 2002 Gujarat earthquake, demonstrates how disasters could also be a reason for distortion of the culture of kinship and reciprocal relationships. He underscores that to minimize the potential encounters with familiar people who have or may have lost their loved ones in the earthquake, individuals began to curtail walking on the streets or around old town areas. Instead, they started spending more time in their own houses watching television. This resulted in the waning of reciprocity, causing decline in collective endeavours among the affected populations (ibid).

Cieslik et al. (2019), in their study conducted in Western Nepal, highlight that disasters can force the affected populations to out-migrate and consequently causes weakening of the kinship bonds and social networks. Likewise, Cannon (2015), in a chapter included in Krüger et al. (2015)'s volume *Cultures and Disasters: Understanding Cultural Framings in Disaster Risk Reduction,* argues that disaster could also prompt people to start doubting the existence of God. These are some examples of how a disaster can profoundly impact local culture and cultural elements, becoming a reason for departure from pre-existing culture, social structure and lifestyles (Hoffman, 2016).

There is a growing call for the incorporation of culture in DRR research and practice. However, cultural dimensions are often undervalued in mainstream DRR research, policies, and practice compared to technical and socio-economic dimensions (IFRC, 2014; Krüger et al., 2015). The complex and arduous nature of cultural framing could be a reason for excluding cultural aspects in DRR research and practice (ibid). In development and humanitarian programs, solutions to DRR problems are often developed by 'outsiders' (Li, 2007; Oven et al., 2017) resulting in a contrast between the perception and priorities of 'outsiders' and local people about risks and solutions (IFRC, 2014). Local people are frequently rendered as passive victims (Marchezini, 2015; Weichselgartner & Obersteiner, 2002) or lacking skills and knowledge of DRR (Maldonado, 2016), maligning their efforts and struggles for risk reduction (Ives, 2004). Local cultures are repeatedly seen as homogenous, tangible, and static (Krüger et al., 2015; Maldonado, 2016) and are often scapegoated as being the obstacles to DRR (Faas & Barrios, 2015; Hewitt, 2011).

Undermining local culture would not only constrain people's willingness to support interventions led by 'outsiders' (Maldonado, 2016) but can also exacerbate rather than reduce their risks and vulnerabilities (Hewitt, 2011). Hence, it is imperative to duly consider a community's cultural aspects for effective DRR (Kulatunga, 2010) and achieving sustainable results (Hiwasaki et al., 2014; IFRC, 2014). The 'pressure and release' model (Wisner et al., 2004, 2012) and political ecology approach (Wescoat Jr., 2015) have the scope to include the role of culture as a factor of safety or vulnerability, but DRR studies and practice following those approaches are often dominated by the analysis of socio-economic and political processes of vulnerability. Other than relating to gender and specific social/ethnic groups, the vulnerability/safety factors are rarely analysed in relation to culture (Cannon, 2008; Hewitt, 2011; Krüger et al., 2015). Often the political and economic aspects subordinate the cultural aspects (Ayeb-Karlsson et al., 2019). It is essential to move beyond the general framing of "policies and practices need to consider local culture" (Faas & Barrios, 2015, p. 292). Cannon (2015)'s BVAB (*Beliefs, Values, Attitudes and Behaviour*) framework presents a useful entry point to better understand the complex links between cultures and disasters.

According to the BVAB framework (Cannon 2015), people's beliefs are deeply rooted in culture, religion, education, and experience. Beliefs enable people to have the explanations of disasters. Values determine what and who are given priority in that culture in relation to risks. Attitudes and perceptions, in turn, are the outcomes of beliefs and values whereas the amalgamation of beliefs, values, attitudes, and opportunities together shapes people's behaviour and responses to risks.

Research indicates that both religious and non-religious interpretations of disaster causes and strategies for risk reduction can coexist (see, for example, Bjønness, 1986; Gergan, 2017; Oven, 2009; Sherry et al., 2018). The attributes of BVAB framework —belief, values, attitudes, and behaviour— are subject to change over time with changes in people's broader experiences of disasters as well as transformation in socio-economic and political settings (Cannon, 2015; IFRC, 2016). As indicated before, considering my research's emphasis on exploring and utilizing local knowledge for knowledge co-production, the subsequent section 2.3.4.2 delves into the literature concerning local knowledge in DRR.

2.3.4.2 Local knowledge in disaster risk reduction

The importance of local knowledge (LK) for DRR is now widely acknowledged (Hermans et al., 2022; Vasileiou et al., 2022; Wang et al., 2019). LK in the context of DRR refers to the knowledge that communities at risk possess and use in observing, anticipating, adapting and communicating risks (Dekens, 2007). It is "acquired through the accumulation of experiences, relationships with the surrounding environment, and traditional community rituals, practices and institutions" (Kelman et al., 2012, p. 13). Because the LK is generated in the immediate context of people's livelihoods (Agrawal, 1995), it is now widely acknowledged that LK is dynamic and undergoes constant modification as the needs, experience, and livelihoods of communities change (Hooli, 2016; Nygren, 1999). Therefore, attempts to create divisions between local and scientific knowledge is pointless (Agrawal, 1995; Dasanayaka & Matsuda, 2022; Hadlos et al., 2022).

LK is often used interchangeably with multiple terms including Indigenous knowledge (IK), traditional knowledge, indigenous technical knowledge, folk knowledge, vernacular knowledge, and traditional environmental knowledge (Dekens, 2007; Kelman et al., 2012;

Šakić Trogrlić et al., 2022). Literature on LK and knowledge integration highlight many benefits of integrating LK in DRR such as getting detailed knowledge of local context, enriching scientific knowledge, helping to address local needs and underlying causes of disaster risks, and encouraging community participation and ownership (Coles & Quintero-Angel, 2018; Šakić Trogrlić et al., 2019).

In addition to the advantages outlined above, LK is also considered to have certain limitations. Many consider the lived experience or memory alone may not be sufficient to foresee the future risks in the rapidly changing global environmental and socio-economic contexts (Barclay et al., 2019; Kelman et al., 2012; Vasileiou et al., 2022). Others think the de-politicised overemphasis on LK and capacities could overshadow the power asymmetries which create the differential vulnerabilities within a community (Cameron, 2012; Hilhorst et al., 2015; Hooli, 2016). The dynamic, invisible, complex, diverse, and context-specific nature of LK makes it challenging for 'outsiders' to identify, understand, and use LK in other contexts (Dekens, 2007; Hilhorst et al., 2015).

In academic and policy discussions, there is a growing call for hybridisation of knowledge to achieve effective DRR (Kelman et al., 2012; Vasileiou et al., 2022). However, in practice, local and scientific knowledge are often treated as opposite or irreconcilable (Gaillard & Mercer, 2012). Consequently, top-down technocratic approaches still dominate the DRR efforts and practical applications (Hadlos et al., 2022; Šakić Trogrlić et al., 2021). The advocates of knowledge integration consider integration as a way to overcome the limits of one knowledge system with the strengths of other (Barahona & Levy, 2007; Hermans et al., 2022; Pottier, 2003). However, integrating local and scientific knowledge is not easy or straight-forward (Cadag & Gaillard, 2012).

Researchers have proposed numerous frameworks for knowledge integration in DRR. Hiwasaki et al. (2014)'s ***L**ocal and indigenous knowledge and practices **I**nventory, **V**alidation, and **E**stablishing Scientific Knowledge* (LIVE Scientific Knowledge) is one of them (see Figure 2.3). This framework emphasizes documentation and subsequent validation and categorization of Local and Indigenous Knowledge (LINK) into four categories namely:

i. Category I, which can be scientifically explained/validated, and related to DRR and/or Climate Change Adaptation (CCA),

ii. Category II, which cannot be scientifically explained/validated, but related to DRR and/or CCA,

iii. Category III, which can be scientifically explained/validated, but not related to DRR and/or CCA, and

iv. Category IV, which cannot be scientifically explained/validated, and not related to DRR and/or CCA.

The framework emphasizes the grouping of LINK to be followed by the integration of *LINK Category I* with science and promotional strategies for wider uptake and further research. However, a key criticism for this framework is the emphasis given to scientific knowledge over the local knowledge in the validation and integration process (Šakić Trogrlić, 2020).

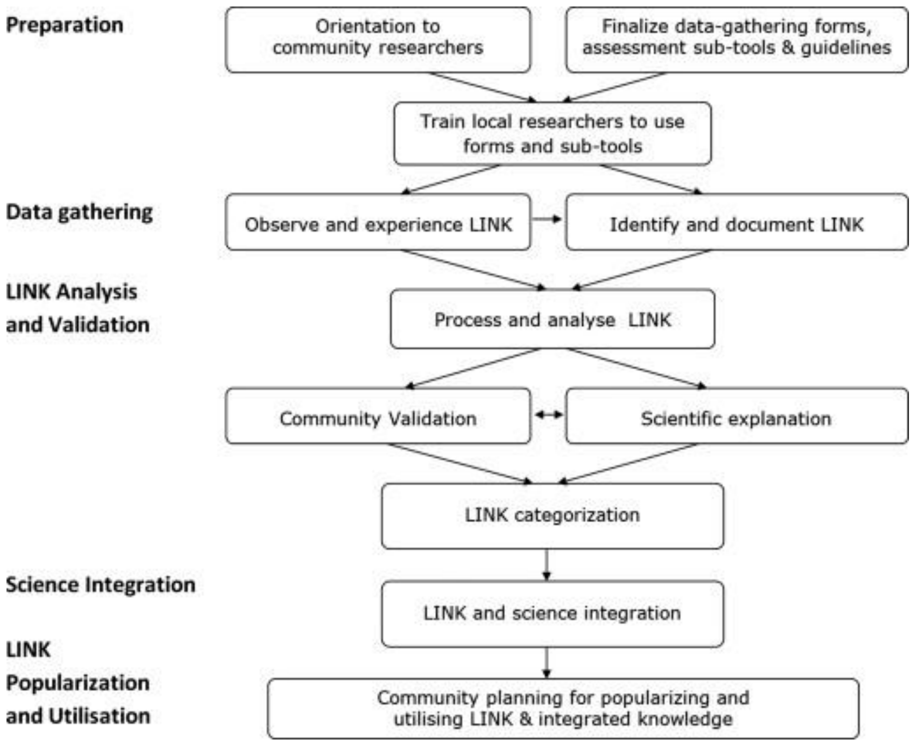

Figure 2.3: Process for integrating local and indigenous knowledge with scientific knowledge (Adopted from Hiwasaki et al., 2014, p. 20*)*

'Process Framework' developed by Mercer et al. (2009, 2010) is another framework for integrating indigenous and scientific knowledge to reduce the vulnerability of communities to environmental hazards. This framework proposes four steps for knowledge integration (see Figure 2.4), which include:

a) community engagement,
b) identification of vulnerability factors,
c) identification of indigenous and scientific strategies and
d) the development of integrated strategy.

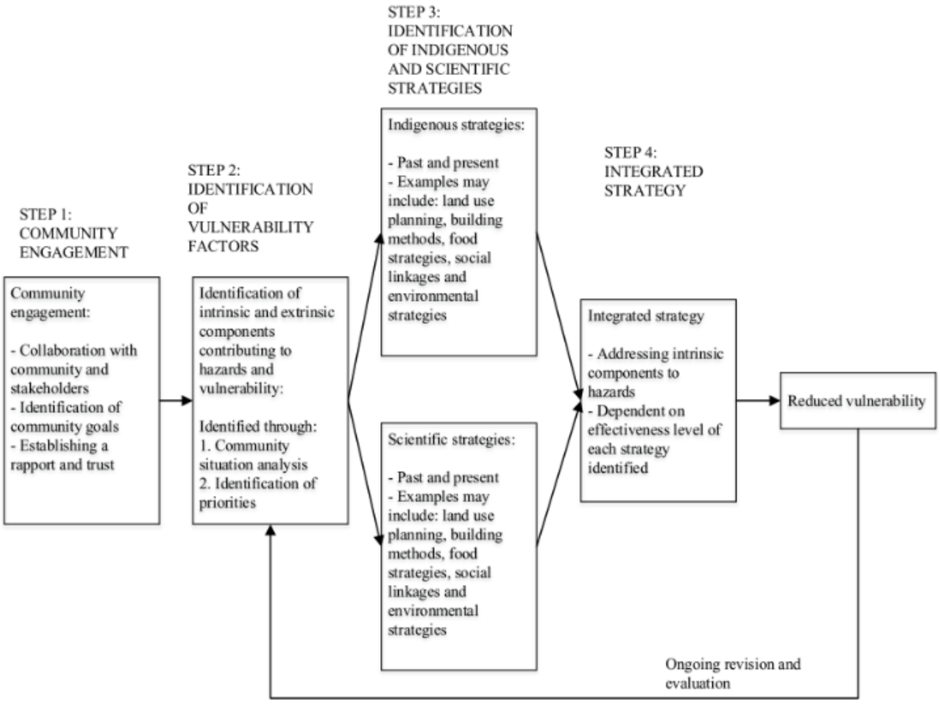

Figure 2.4: Process framework for integrating knowledge (Adopted from Mercer et al., 2010, p. 220*)*

Although Mercer et al.'s framework (2010) is a promising approach for knowledge integration, it tells little about how the community engagement and the integrated strategy will be achieved (Briggs, 2013). Gaillard & Mercer (2012)'s roadmap for integrating knowledge, actions, and stakeholders for DRR (see Figure 2.5) partly addresses these concerns by emphasizing 'dialogue' between the 'inside' and 'outside' actors for achieving the integrated strategy.

However, 'dialogue' and the use of participatory tools, as suggested in Gaillard & Mercer (2012) and Mercer et al. (2010) respectively, should not be understood as a 'silver bullet' solution for addressing the diversity and complexity of community issues (Clark-Ginsberg, 2021). As Cooke & Kothari (2001), Mubita et al. (2017), Cornish et al. (2023), Nightingale (2005, 2017) and many others have highlighted, participatory processes including consultations, discussions, dialogues or use of other participatory vulnerability capacity assessment tools, are often susceptible to manipulation by 'outsider' individuals or organizations, often favouring the interests of elite groups that results in disproportionate benefits for certain individuals or groups.

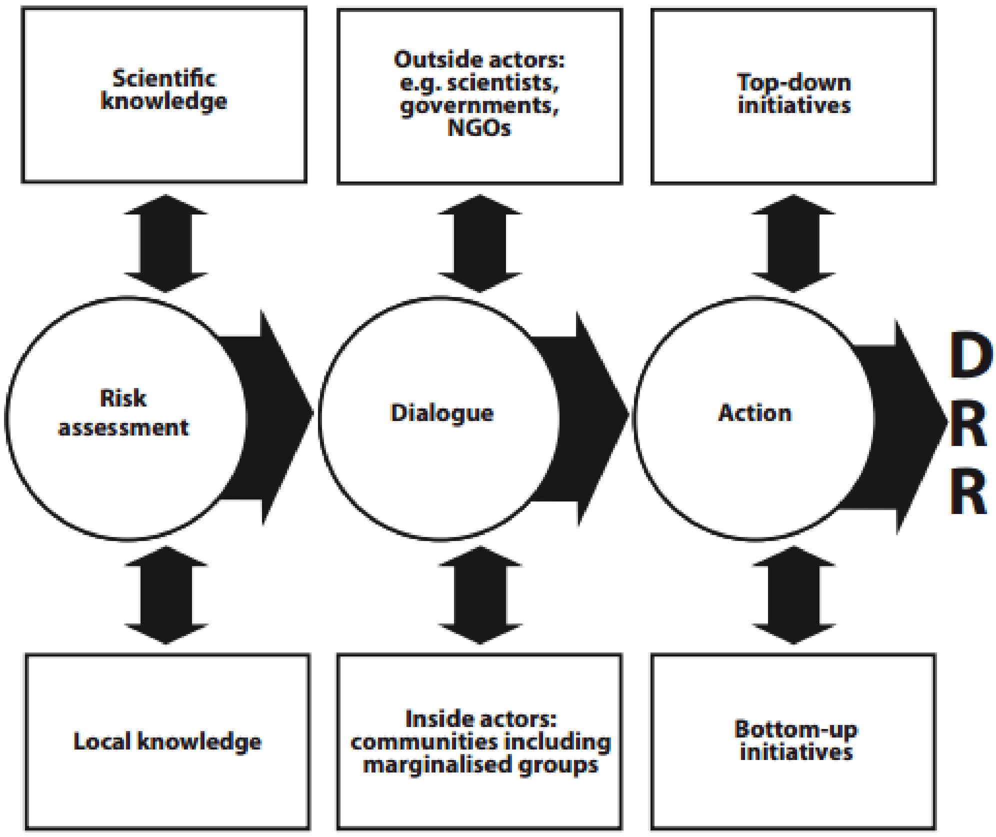

Figure 2.5: Road map for integrating knowledge, actions, and stakeholders for disaster risk reduction (Adopted from Gaillard & Mercer, 2012, p. 95*)*

All the frameworks discussed above (Gaillard & Mercer, 2012; Hiwasaki et al., 2014; Mercer et al., 2010) tend to portray LK as homogenous and something that is isolated from scientific/'outside' knowledge, reflecting other common limitations of most frameworks. In reality, LK is inherently hybridised through its intersection with multiple knowledge sources and systems (Balay-As et al., 2018; Baumgartner et al., 2004; Hadlos et al., 2022). Additionally, these frameworks do not give adequate attention to critical factors, such as uneven power dynamics within communities as well as between the most risk groups and 'outside' actors, heterogeneity of knowledge within a community, perceived supremacy of the 'outside' or scientific knowledge, cultural and language barriers, the intangible nature of local strategies, and lack of consensual tools and methods trusted by all stakeholders, including local people, government officials, scientists and NGO workers (Mercer, 2012).

In academic discourse, participatory mapping (Cadag & Gaillard, 2012), participatory three-dimensional mapping (Kusratmoko et al., 2017) and the use of a live physical three-dimensional demonstrator (Basyal, 2021) are presented as some of the potential tools for facilitating participation and dialogue between different stakeholders. Similarly, Gaillard et al. (2016) have highlighted the potential of 'participatory numbers' to foster dialogue between local communities and a wide range of stakeholders, and to bridge the gap between local and scientific knowledges. However, it is essential to recognize that in all participatory processes, the process itself is as crucial as the tools used for knowledge integration and co-discovery of solutions (Mercer, 2012). Section 2.3.5 shines additional light on the participatory approaches to DRR research and practice.

2.3.5 Participatory approaches to disaster risk reduction

A large body of literature suggests the dominance of top-down approaches in DRR efforts where physical science and technology are given more emphasis than understanding citizens' requirements and better ways of engaging them (Baczynski & Bar, 2017; Fakhruddin & Chivakidakarn, 2014; Marchezini et al., 2017, 2018; Pecoraro et al., 2018; Preuner et al., 2017). While such top-down approaches may bring some immediate benefits to the communities involved, they are often criticized for failing to generate long-term benefits and to empower people to address the root causes of disaster risks (Oven et al., 2019). Such approaches are generally designed by 'outsiders'—scientists or DRR 'experts,' who have very little understanding of the local context and root cause of vulnerability, and give too much focus on altering the hazard (Hilhorst et al., 2015; Kelman et al., 2012). Frequently, such top-down approaches are imposed on local communities without consideration of their own indigenous knowledge and local needs (Rai & Khawas, 2019; Vasileiou et al., 2022). Such measures can be difficult to understand for many local people and hence, fail to give durable results (Gaillard et al., 2016). Consequently, this increases the lack of ownership and sustainability in DRR initiatives (Šakić Trogrlić et al., 2019).

In response to the limitations of top-down approaches to DRR, bottom-up and participatory approaches are increasingly promoted to address the challenges to DRR (Marchezini et al., 2018; Nadiruzzaman & Wrathall, 2015). Participatory approaches have their roots in the rural development sector (Chambers, 1994) and emerged out of a growing recognition of the shortcomings of top-down development approaches in failing to achieve sustainable outcomes (Cooke & Kothari, 2001). Now, participatory approaches are promoted in a wide range of sectors including development (see, for example, Mubita et al., 2017), natural resource management (see, for example, Wagley & Ojha, 2002; Xu et al., 2012), DRR (see, for example, Baudoin et al., 2016; Gaillard et al., 2016), climate change adaptation (see, for example, Cash, 2021; Moser & Stein, 2011; Nagoda & Nightingale, 2017), migration studies (see, for example, Bhagat, 2022) and many more. Participatory mapping, transect walks, problem trees, group interviews and discussions, historical timelines and seasonal calendars, ranking and scoring, storytelling, role-playing, use of mock-ups showing the spatial elements etc. are some of the commonly used tools in participatory processes (Chambers, 1994; Gaillard & Mercer, 2012; McCall & Peters-Guarin, 2012; Mendonca & Valois, 2017).

In disaster research and practice, community-based disaster risk reduction/management (CBDRR/M) (Abarquez & Murshed, 2004), citizen science (Hicks et al., 2019; Paul et al., 2018) and participatory action research (Lane et al., 2011) are three of the popular approaches promoting people's participation. These three concepts and approaches are closely related but differ slightly in their goals, objectives, and nature and levels of people's engagement. CBDRR/M, generally, encompasses the collaboration between the supporting agencies (such as NGOs, government institutions, research institutions etc.) and community to identify, analyse and reduce the disaster risks they face (Maskrey, 2011). Likewise, citizen science and participatory action research, in general, represents a form of collaboration between the general public and researchers primarily aimed at—though not limited to—knowledge co-creation. While citizen science primarily refers to the engagement of public in collection, sharing, analysis and dissemination of data for knowledge co-production (Bonney et al., 2009), participatory action research represents the collaborative action-oriented research on social issues and involves the iterative cycle of actions and reflections (Frediani & Nussey, 2021).

Scholarship on disaster has explored different pathways, benefits, and challenges of public participation in disaster research and practice. Izenberg et al. (2022), for example, conducted a series of interviews and participatory workshops to identify the challenges encountered in landslide risk financing in Alaska and to catalyse new public-private partnerships useful for overcoming obstacles to risk financing. Stone et al. (2014) highlighted how the network of local volunteers in Ecuador known as *vigías* contributed to monitoring and communication of volcanic risk around Tungurahua volcano. They further highlighted that the functioning of the network was reliant on the perceived probabilities of hazard occurrences and the interpersonal relationships with the scientists but was negatively affected by the reduction in the funding allocation from the government authority that was necessary to ensure a functioning communication system. This echoes Rotman et al. (2014)'s opinion about the challenge of participatory research in keeping volunteers motivated over extended periods of time in research.

Rollason et al. (2018) highlighted how flood risk communication strategies in Northumberland in the UK were improved by collaborating with the local research/project beneficiaries. Jacobs et al. (2019) piloted the concept of participatory sensing in Uganda for collecting data using smartphone technology to improve knowledge and understanding of disasters and demonstrated the potential value of engaging local collaborators in collecting detailed information on disasters happening in remote data-scarce locations where the permanent field presence of researchers is not feasible. Meanwhile, Marchezini et al. (2017) explored how the engagement of schools and students in participatory mapping and landslide monitoring contributed to identifying the challenges and solutions for landslide risk reduction. They also highlighted the important role played by the students in disseminating risk information to their friends and families when the rainfall exceeded the pre-determined thresholds.

Overall, the participatory approaches to DRR research and practice have the potential to contribute to DRR by ensuring inclusiveness of different forms and scales of knowledge (Gaillard & Mercer, 2012; Marchezini et al., 2017). They help in generating greater trust, legitimacy, ownership, and governance, and speeding up the decision-making in DRR efforts (Marchezini et al., 2018; Whitman et al., 2015). Through openings for knowledge exchange (Mercer et al., 2009), participatory approaches bring the opportunities to gain from what Barahona & Levy (2007) describe as the 'best of both worlds.' They can amplify the voices of excluded and marginalized groups (Gumiran & Daag, 2021) and help resolve contested issues ensuring a 'win-win' situation in cases of divergent opinions, confrontations, or expectations (Preuner et al., 2017; Scolobig et al., 2017). They have the potential to empower beneficiaries and foster trust in supporting agencies (Chambers, 2007).

Principally, participatory approaches entail active involvement of beneficiaries in decision-making regarding the processes and interventions that affect them or their lives, with 'outsiders' simply playing the roles of facilitators (Cooke & Kothari, 2001). In development programmes and social science research, such process of passing authority to people is described as 'handing over the stick' (Chambers, 1994; Gaillard et al., 2016; Moser & Stein, 2011). However, such approaches are not free from limitations and criticisms. A major critique of participatory research and projects is that people's participation is often limited to nominal or passive participation (Agarwal, 2001; Pretty, 1995). Participatory approaches are often used as a managerial exercise (Cleaver, 1999) to impose, lubricate, or formalize top-down plans and agendas (Cooke & Kothari, 2001; McCall & Peters-Guarin, 2012). In Arnstein (1969)'s terms, participation where the citizens have limited role or power is deemed tokenistic participation. The absence of meaningful participation does little to reduce people's risks and vulnerabilities (Weichselgartner & Obersteiner, 2002).

Another common criticism of participatory projects is that rather than recognizing socially embedded informal structures and relationships, agencies emphasise establishing more formalized structures, such as committees (Cleaver, 1999, 2001). As shown by Nightingale (2005) in the context of Nepalese community forest management, such approaches privilege the local elites instead of socio-economically marginalized people. Poorly or improperly executed participatory approaches can exacerbate suspicion, conflicts, blame and frustration (Tseng & Penning-Rowsell, 2012), and may not necessarily overcome subordination, inequality, exclusion, or vulnerability (Cleaver, 1999; Gladfelter, 2018). Instead, they may contribute to entrench and reproduce pre-existing power relations (White, 1996). Nadiruzzaman & Wrathall (2015) compare such situation to the 'antidote becoming the poison' (p. 197).

Hence, to ensure the success and effectiveness of participatory approaches in DRR, underlying questions about who is involved, how, and on whose terms must be carefully considered (White, 1996). Participatory approaches simply should not be seen as a panacea to social problems and issues (Cooke & Kothari, 2001). Critical attention is needed to challenge pre-existing power and resource asymmetries (Pelling, 2007; Preuner et al., 2017).

2.3.5.1 Participatory Action Research for knowledge co-production

In most instances, participatory action research (PAR) and participatory research including citizen science are used synonymously. However, some authors suggest PAR is different from participatory research for its added focus on social action or transformation on top of knowledge generation (Kindon et al., 2007; Taylor et al., 2004). In participatory action-oriented research, 'certified' and 'non-certified' scientists complement each other's knowledge (Lane et al., 2011). They define common research questions and share responsibilities within existing institutional and social settings (Whitman et al., 2015). Unlike the curiosity-driven approach of most research, PAR focuses on actionable knowledge production based upon people's issues and concerns with the aim of bringing about positive change (Kelman et al., 2011).

Many believe PAR is grounded in Paulo Freire (1970)'s work on grassroots activism in education (Kindon et al., 2007; McCall & Peters-Guarin, 2012; Whitman et al., 2015), the idea being: 'nothing about us without us' and 'researching with, not on' (Atkins, 2013; Bell & Pahl, 2018; Charlton, 1998; Tanabe et al., 2018). The PAR approach gives more voice and agency to the historically excluded and marginalized groups (Gumiran & Daag, 2021). In PAR, local people are regarded as full partners in comprehending a problem and co-producing workable (if not final) solutions (Kelman et al., 2011; Ozanne & Saatcioglu, 2008; Tran & Kim, 2023). Most importantly, PAR recognizes the plurality of knowledges and treats individuals from systematically excluded and historically oppressed groups as competent and equal partners in all aspects of the research-informed actions (Kindon et al., 2007; Pain et al., 2007). Put differently, the research participants are treated as 'collaborators', rather than a data source (Gumiran & Daag, 2021; Izenberg et al., 2022).

In the realm of DRR, PAR has been applied in various studies. For instance, Lane et al. (2011) conducted PAR on flood risk reduction in Pickering, North Yorkshire, UK. Unlike the conventional practice in the UK where 'certified' scientists or consultants undertake the flood risk research, their study involved collaboration between the academic scientists and 'uncertified' experts to co-develop the 'bund model' for flood risk management in Pickering with notable success.

Other notable examples of PAR include the works of Ruszczyk et al. (2020), Cadag & Gaillard (2012) and Smith et al. (2022). Ruszczyk et al. (2020)'s work empowered the participating women from the rural and urban neighbourhoods of Nepal with the knowledge, skills, and resources to identify and mitigate the risks of hazards concerning them. On the other hand, Cadag & Gaillard (2012) demonstrated the effectiveness of Participatory Three-Dimensional Mapping (P3DM) as a tool for integrating local and scientific knowledge in assessing disaster risks, identifying potential strategies, and transforming those strategies into a comprehensive action plan in Masantol Municipality in the Philippines.

Similarly, Smith et al. (2022) conducted semi-structured interviews in the informal neighbourhoods of Brazil and Colombia to map perceptions and narratives of landslide risks. Furthermore, they utilized a combination of transect walks and participatory mapping exercises to identify sites for landslide monitoring and potential mitigation works. Community volunteers were trained and engaged to capture consistent photographs of monitoring sites, which were subsequently analysed during the community workshops to assess landslide risks and potential mitigation measures. Furthermore, the community implemented low-cost emergency landslide mitigation works, focusing on rainwater and wastewater management, based on their enhanced understanding of ground stability and its possible connection with rainwater and wastewater.

The aforementioned examples illustrate that PAR is more about a process or approach that proceeds through the cycles of action and reflection rather than about the certain methods mapped out in advance (Kindon et al., 2007; Ruszczyk et al., 2020; Whitman et al., 2015). It serves to contribute to the empowerment of participants by tying the 'external' purpose and 'internal' demands (McCall & Peters-Guarin, 2012) and contributes to the initiation of context-specific knowledge-informed actions (Smith et al., 2022). However, like in all other participatory processes, PAR process requires a sound facilitation to foster dialogue ensuring a positive group dynamic throughout the process (Lane et al., 2011; Whitman et al., 2015). In sum, carefully executed PAR enables the co-production of applicable, appropriate, and contextual solutions to DRR issues (McCall & Peters-Guarin, 2012).

2.4 My approach

In this thesis, I consider not only the low frequency-high magnitude events but also the high frequency-low magnitude landslide events as falling under the categories of disasters, provided they result in loss of lives, livelihoods and/or wellbeing of households and communities. For the purpose of my research, I adopt a slightly modified definition of disaster given by Wisner et al. (2012). I consider disaster as:

"a situation involving a natural, [*socio-natural, anthropogenic, and/or technological*][3] hazard which has consequences in terms of damage, livelihoods/economic disruption and/or casualties that are too great for the affected area and people to deal properly on their own."

-Adapted from Wisner et al. (2012, p.30)'s definition of disaster

There is a lack of universally accepted meaning and criteria for small-scale disasters in academia and global policy arena (Tennakoon et al., 2023). This may underscore the underestimation of small-scale disasters on one hand, but on the other, could also reflect the challenge in defining something that is extremely relative and contextual. Shrestha & Gaillard (2013) provide one of the few definitions available, proposing to define small-scale disasters as the "events that cause damage, destruction and suffering in people's lives at a scale greater than that of daily hardships (associated with poverty, poor health and food insecurity) but lesser than that of major disasters" (p. 46). Informed by Spivak (1987)'s perspectives, Gaillard (2022a) highlights that although establishing the precise definition of something may be impossible, having definitions helps us in informing our choices and guiding our actions. Therefore, I find Shrestha & Gaillard (2013)'s definition of small-scale disasters, encompassing events that do not meet the EM-DAT's disaster criteria but are different from 'everyday' hardships and have a significant material and psycho-social hefts on the affected populations, could be useful to indicate the small- and medium-scale landslides of interest in my study areas.

[3] The words in italic fonts inside square brackets have been added to widen the scope of definition of disaster in my research.

Being conscious of the insights and critiques of different theories and concepts of DRR outlined in Sections 2.2 and 2.3 above, this thesis seeks to assess the deeper socio-political, economic, and cultural dimensions of risk by employing a political ecology and cultural approach. Working at the intersection of these approaches helps to better understand people's vulnerability, and knowledge and strategies of historically marginalised groups such as the Tamang people of the Nepal's Himalayas, in relation to landslide risks (Chapter 5). The insights gained from these approaches will also facilitate the collaborative development of a landslide monitoring system blending local and scientific knowledges (Chapters 6 and 7).

Chapter 3 Methodology

3.1 Introduction

Chapter two presented the key concepts that underpin this research. In this chapter, I detail the methodological frameworks that were adopted to address the overarching aim and three research questions. Beginning with the presentation of research site's context and their selection process, this chapter then discusses fieldwork including engaging with research assistants, consent, positionality, and ethics. The chapter then describes data collection and analysis, and ends by reflecting on the experience of doing fieldwork amidst the COVID-19 pandemic.

3.2 Study area

My study areas lie in the Barhabise Municipality of Nepal's Sindhupalchok district (Figure 3.1)—one of the districts most affected by the 2015 Gorkha earthquake (Bownas & Bishokarma, 2019; Kincey et al., 2021). More than 1% of the district land surface area is covered by landslides (Rosser et al., 2021), and over 20% is considered to be at high to very high landslide susceptibility (Shrestha et al., 2017). While Nepal and Sindhupalchok District were chosen purposively because of the high landslide vulnerability (Froude & Petley, 2018; McAdoo et al., 2018), the case study villages -Mathillo Sigarche and Tallo Sigarche- were chosen using a combination of a secondary data review, stakeholder consultation and reconnaissance visits to potential sites.

Firstly, landslide hazard and susceptibility maps prepared by Kincey et al. (2021) and the geo-hazard risk categorization conducted by the National Reconstruction Authority (NRA) after the 2015 Gorkha earthquake were reviewed. The NRA was mandated by the Nepalese government to lead and manage the recovery and reconstruction of the damage caused by the 2015 Gorkha earthquake (Oxford Policy Management, 2020). The NRA conducted geohazard assessments of over 1000 settlements in the 14 most earthquake-affected districts and classified them as Category 1, 2 or 3 (Rieger, 2021). Among these, Category 1 were considered as safe locations; Category 2 were unsafe but with risks manageable following appropriate measures for risk reduction; and Category 3 were very unsafe settlements unsuitable for continued habitation, and were recommended for relocation to other safer areas because of the higher risks of geohazards that are extremely difficult to control for technical and financial reasons (Oven et al., 2021).

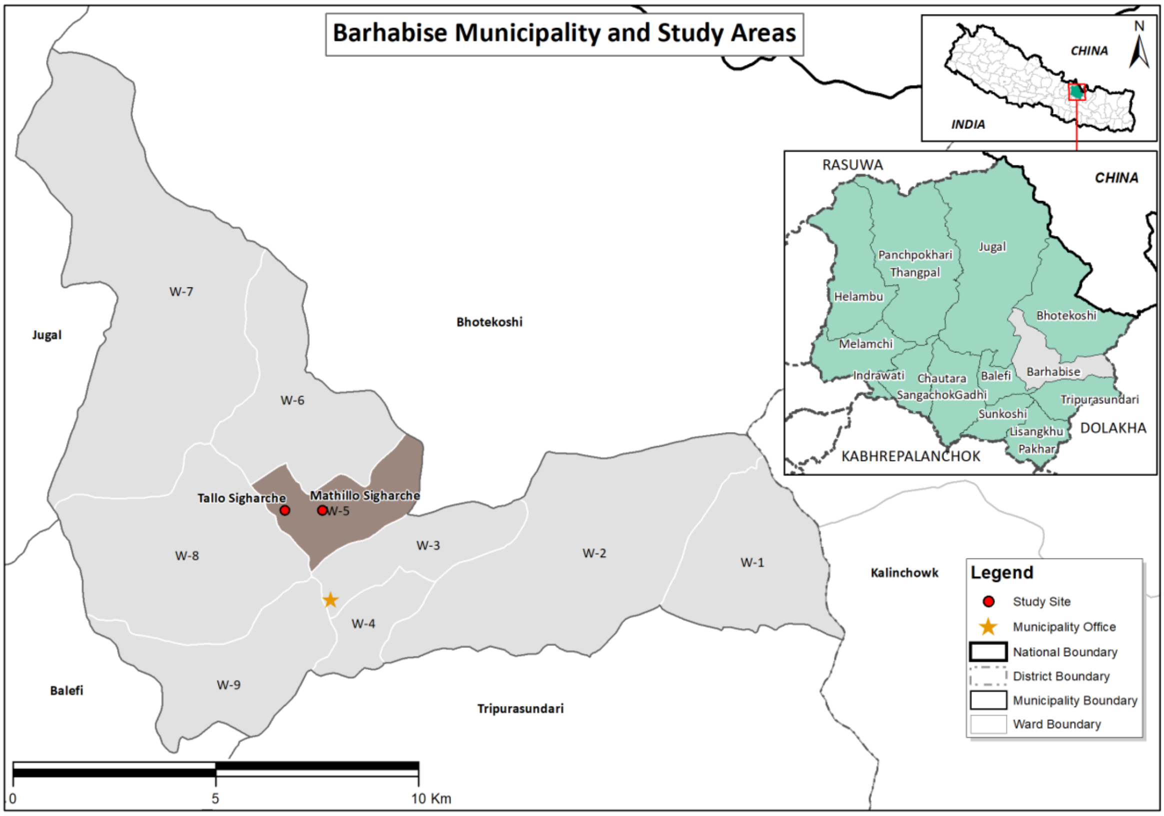

Figure 3.1: Map showing the locations of the study areas in Sindhupalchok District's Barhabise Municipality of Nepal

The criteria set for shortlisting sites for my research encompassed Category 2 settlements and where landslide monitoring had been suggested as a potential measure for risk reduction. This was followed with consultation with national- and district- level authorities and DRR researchers and practitioners, in addition to reconnaissance visits to potential locations, and consultations with local authorities, social workers, and community members during fieldwork between December 2019 to January 2020. During this course, I visited 12 villages across Sindhupalchok and ultimately selected Mathillo Sigarche and Tallo Sigarche within Barhabise Municipality. The following criteria were considered:

- Occurrence of frequent but less extreme small- to medium-scale landslides (< ca. 100 m in length),
- Expression of interest from community members and local authorities in contributing to the wider research including landslide monitoring,
- A maximum of 3 hours walk from the highway, to ensure the villages are reachable by foot during the monsoon.

Mathillo Sigarche and Tallo Sigarche lie in the Lesser Himalaya, with the local geology dominated by sedimentary and metamorphic rocks including shale, sandstone, limestone, slate, phyllite, schist, metasandstone, dolomite, quartzite, and carbonate rocks (Dhital, 2015; Stocklin, 1980; Upreti, 2001). These villages are linked to the Araniko Highway via an unmade rural road approximately 7 km and 4 km respectively from the highway, and 11 km and 8 km from Barhabise Bazaar[4](see Figures 3.2 and 3.3). The bazaar serves as the central location for the Municipality office, and nearest market, banking, and primary health care facilities. The road access to the study villages gets damaged at multiple points during the monsoon with repairs conducted after the monsoon ends. Even during dry season, local people mostly commute on foot to reach the highway due to limited public transport. If lucky, people get a lift on a lorry or a jeep which are hired by local retailers or contractors to transport construction materials and other essentials to the villages. Very few people own private motorbikes.

[4] Bazaar refers to local marketplace.

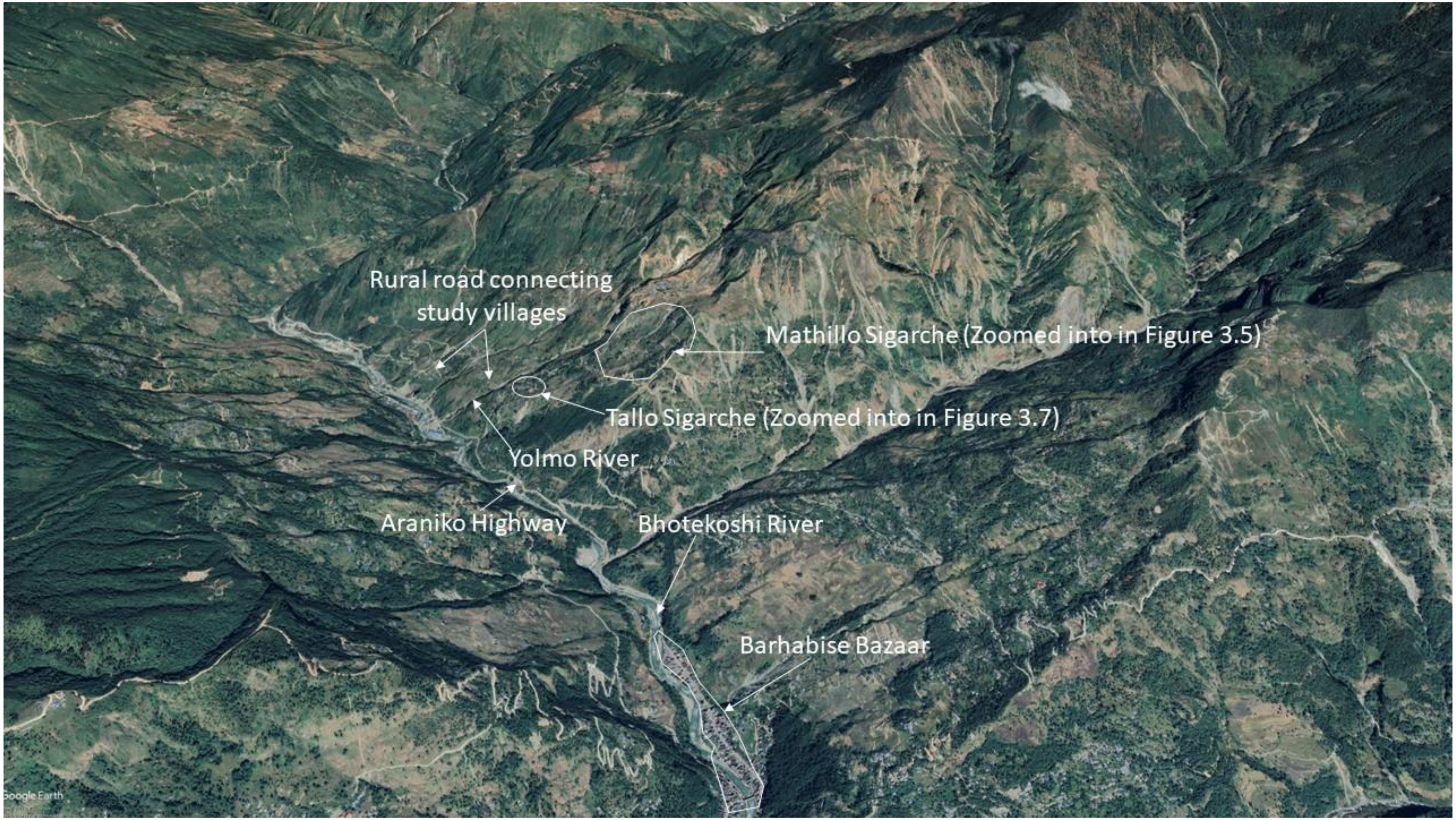

Figure 3.2: Google Earth image (Zoomed out) showing study areas, Barhabise Bazaar, Bhotekoshi River, Araniko Highway and rural roads connecting study villages

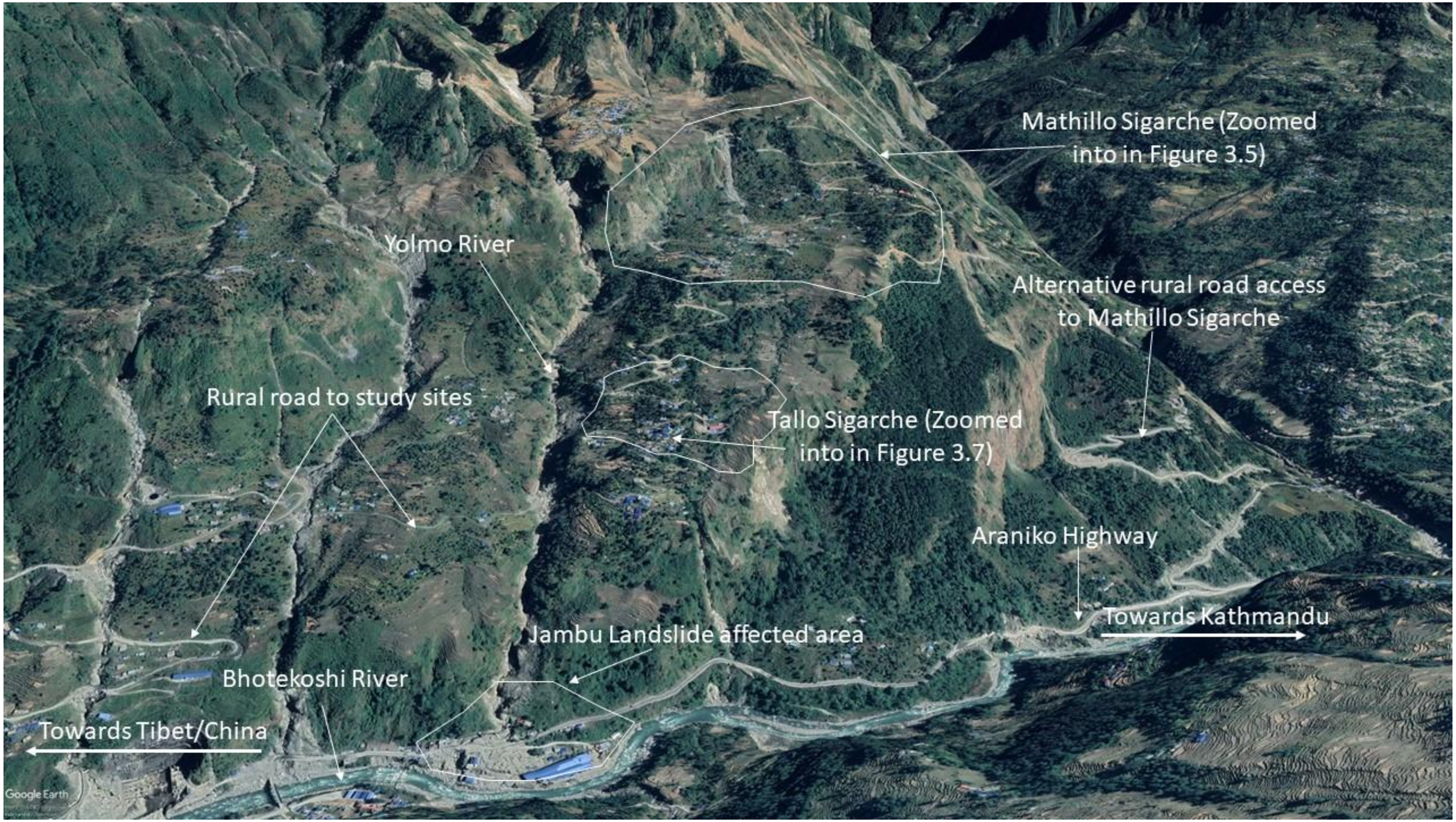

Figure 3.3: Google Earth image (Zoomed into) showing study areas and some key features

3.2.1 Mathillo Sigarche

Mathillo Sigarche is a Tamang village at ca.1600 meters above sea level (masl) with around 80 households (see Figures 3.4 and 3.5). Moktan, Theeng, Rumba, Dong, and Yonzon are the major clans or *Rui* in the village, and I use the term 'Tamang' to refer to the whole village population irrespective of their sub-caste. There are at least 5 sub-settlements, or locally *Tole*, namely Karthali, Lama, Ghyang, Kondong and Bich, each with clustered but widely dispersed houses distributed across the hillside. The village connects to the Araniko Highway by two rural roads. Mirroring the mountain roads across Nepal, these rural roads encounter failures at multiple locations during monsoon (Sudmeier-Rieux et al., 2019).

Maize, millet, and wheat are the major crops. Paddy is planted in some lower lying areas. While oxen are raised for agricultural purposes, villagers raise goats and chickens for both domestic consumption but also to generate supplementary income. Agriculture and livestock rearing have never been sufficient to sustain the families who have relied on seasonal migration to work in quarrying, road construction, agriculture, and porterage in Kathmandu and the nearby Khasa *bazaar* (market area) at the Nepal-China border. Seasonal migration has now largely been supplanted by extended overseas migration to the Gulf and Malaysia.

Figure 3.4: A view of Mathillo Sigarche Village from the top of the village

Figure 3.5: Google Earth image (Zoomed into) showing Mathillo Sigarche

3.2.2 Tallo Sigarche

Tallo Sigarche is a mixed settlement of Chhetris, Newars and Brahmins with around 45 households and is located at ca. 1200 masl (see Figures 3.6 and 3.7). In contrast to Mathillo Sigarche, Tallo Sigarche has a greater area of productive land, and diversity and productivity of crops. This encompasses notably larger areas of rice terrace, maize fields, and plots to grow varieties of vegetables enabling them to sell surplus produce to the workers at the Mid-Bhotekoshi hydropower project situated downslope as well as at nearby Barhabise Bazaar. Overall, Tallo Sigarche exhibits relatively better conditions in terms of household income, land ownership, education, and access to local and district level government and non-government authorities compared to Mathillo Sigarche. Connection to government and non-government agencies is reflected in the form of a greater number of local development projects such as road construction or maintenance, and public buildings providing alternative income generation opportunities within the village as local contractors, and skilled or unskilled workers. Besides these, livestock rearing, foreign employment, informal retail trade and jobs in government and the private sector are other sources of income of residents of Tallo Sigarche.

Figure 3.6: Drone image of Tallo Sigarche Village (Photo Credit: People in Need, 2022. Photo published with permission)

Figure 3.7: Google Earth image (Zoomed into) showing Tallo Sigarche

It is worth mentioning that due to the impacts of the COVID-19 pandemic on my research, the in-depth ethnographic approach aimed at investigating the socio-cultural institutions and processes influencing knowledge and strategies (related to Research Question 2) was implemented exclusively in Mathillo Sigarche only. Conversely, the research in Tallo Sigarche was centred around co-producing the landslide monitoring system (related to Research Question 3) within the premises of the local primary school. The collaboration in Tallo Sigarche involved the school management committee members and some nearby residents.

The COVID-19 pandemic caused a more than year-long hiatus in my fieldwork, necessitating adjustments to my research focus and approach on at least three occasions. The original intention was to maintain similar levels of engagement in both Mathillo Sigarche and Tallo Sigarche, to compare the findings from historically marginalized ethnic groups, namely the Tamangs living in Mathillo Sigarche, and the relatively better-off people consisting of Chhetris, Newars and Brahmins of Tallo Sigarche. However, comprehensive participant observation was feasible only in Mathillo Sigarche, while my engagements in Tallo Sigarche mainly concentrated on the landslide monitoring aspect of the research. I supplemented my research in Tallo Sigarche with a series of in-depth semi-structured interviews, informal conversations, and focus group discussions. However, these discussions primarily addressed Research Question 3, and the intensity and breadth of engagement focusing Research Question 2 were relatively lower than compared to Mathillo Sigarche. Consequently, the plans to compare the findings in relation to Research Question 2 do not form part of this thesis.

An additional research question (Research Question 1), not initially planned, was incorporated to utilize the 'stay-at-home' mandates during the COVID-19 pandemic in doing research. The exploration for Research Question 1 was based on a systematic literature review (Parris & Peachey, 2013) and mapping of studies (Peters et al., 2015) that could be conducted working from the UK during the pandemic. The impact of the COVID-19 pandemic on my research is elaborated further in Section 3.7.

3.3 Fieldwork practicalities and arrangements

In this section, I describe the practical aspects of my fieldwork conducted between the second week of May 2021 to second week of October 2022.

3.3.1 Research assistant

Accounting to my limited proficiency in the Tamang language and the anticipated language barrier with the residents of Mathillo Sigarche, I hired a local research assistant (Suren[5]), now a friend, aged 28, to act as a translator for support. I first met Suren by chance one day in June 2021 while he was guarding his maize field against monkeys. I was soon impressed by his understanding of the local issues, including those related to small-to medium-scale landslides that aligned with my research interests. He was energetic, had basic literacy and was able to speak both Tamang and Nepali. Being a local resident who practiced seasonal relocation during the monsoon to nearby public land, he was also able to offer valuable first-hand insights about these issues. In Tallo Sigarche, where my involvement was less intensive compared to Mathillo Sigarche and where the primary participants were proficient in Nepali, I did not feel the need for a research assistant. The teachers and members of the school management committee contributed significantly to the research, effectively filling any potential gaps that might have arisen in the absence of a research assistant.

Suren's role was instrumental in enriching the value of my research. During the initial months, he facilitated my introduction to other villagers. He also helped me understand and triangulate the local context, issues, cultural beliefs, values, customs, and power dynamics. I was lucky to find out that most of the villagers could also speak Nepali, allowing me to gradually engage independently in informal conversations and semi-structured interviews as my rapport with the community strengthened. This allowed Suren to spend less time with me as the research progressed.

While his role diminished, his support remained crucial in organizing and facilitating focus group discussions, as well as in managing logistics during the installation of the landslide monitoring instruments. Suren also assisted in translating and interpreting complex idioms, phrases and verses of songs intermittently used by villagers during our interactions. Although I often attempted to seek explanations directly from participants, if any difficulty arose, I noted them for future discussion and reflection with Suren. Overall, Suren's contribution surpassed

[5] Pseudonym have been given to ensure anonymity.

the practicalities and expectations. I am profoundly grateful for his invaluable support to my research.

3.3.2 Gaining consent

All semi-structured interviews and focus group discussions began with an explanation of their purpose and my intended use of the information gathered. Additionally, I explained the details included in the project information sheet, consent form and project summary sheet, which I had prepared as part of gaining ethical approval for my fieldwork from Durham University (see Appendices 1-3). When the participants expressed interest in obtaining the copies of these documents, I happily distributed them. Before starting any interviews or focus group discussions, verbal consents were taken (Atkinson & Hammersley, 2007) assuring them of the confidentiality and anonymity (Banks & Scheyvens, 2014). Furthermore, participants were made aware and asked to give additional consent if any of the conversations or discussions were recorded.

However, prior consent was not always practical, especially during the more opportunistic informal conversations that yielded valuable and relevant information. In such circumstances, approval was taken subsequently to document the information for use in the research. This was accompanied with an explanation of the research objectives, and the significance of their information, along with the assurance of anonymity. Each participant has been assigned a pseudonym in this thesis, and any photographs revealing identity and all quotes (though anonymised) used in this thesis have been included only with participants' approval.

3.3.3 Positionality

A researcher's positionality, encompassing factors such as age, gender, socio-economic status, ethnicity, and level of education plays a crucial role in social science research (England, 1994; Skelton, 2001). I am from Kathmandu, the capital city of Nepal, and belong to the Newar ethnic group considered as privileged relative to Tamang people of Mathillo Sigarche and the Chhetris, Newars and Brahmins of the Tallo Sigarche, both sites representing predominantly rural setting. Additionally, the reality that I was pursuing my education from a University in the UK, placed me in a further privileged position in the eyes of villagers as very few local people had education beyond secondary school. These backgrounds posed certain challenges for me as being viewed as an ‘outsider’, potentially influencing my access to participants or the nature of information provided to me (Lavers, 2007; Yip, 2023).

My positionality transformed when interacting with other key informants, such as authorities, practitioners, or researchers. I was familiar to most of them from my previous role as a development practitioner, but I explained my transition to the role of a researcher. While talking to them, I tried to present myself as neutral, but there were moments when I think my body language and word selection presented me as having genuine concern for local issues. Furthermore, questioning the approaches of development agencies, to which I had recently belonged, sometimes felt uncomfortable. Such fluidity in the researcher’s positionality, as emphasized by Yip (2023), Milligan (2016) and many others, indicates the situational and dynamic nature of the researcher’s positionality.

Throughout my fieldwork, I constantly worked towards diluting the effects of positionality through my everyday activities and efforts towards building rapport. Despite being offered chairs or beds due to my perceived higher status—a customary display in Nepal for showing respect to elders and people with a higher social-cultural status—I consciously sat in similar positions as local people. For example, if they were sitting on straw mattress (called *gundri* in Nepali), I sat on same, and if they were sitting on flat wooden plank (called *pirka* in Nepali), I sat on the *pirka* too (see Figure 3.8). My efforts to learn the local Tamang language and culture using a handbook called the ‘Tamang Tam’ (Yonjon-Tamang, 2021), were instrumental in fostering my local connections. Though I only had limited proficiency in Tamang, the community appreciated my efforts, resulting in enhanced rapport and attachment.

My professional training in the I/NGO sector meant I could knowingly or unknowingly be biased towards favouring top-down technocratic measures or endorsing people’s participation in the same manner which many critics have highlighted as problematic (Cooke & Kothari, 2001; Nightingale, 2005, 2017). However, the background reading and research, including my extensive review of community-based landslide risk reduction studies (Chapter 4) and regular supervision meetings with my supervisors from different disciplinary backgrounds and expertise, allowed me to critically evaluate my past approaches. This reflection instilled in me a dedication to promote meaningful participation of individuals in my research (Cleaver, 1999). To ensure this commitment, deliberate caution was taken to prevent ‘elite capture’ (Cooke & Kothari, 2001). Meetings or conversations were organized at the times and locations convenient for my research participants, and due respect and attention was given to their experiences, culture, knowledge and perceptions (Hadlos et al., 2022).

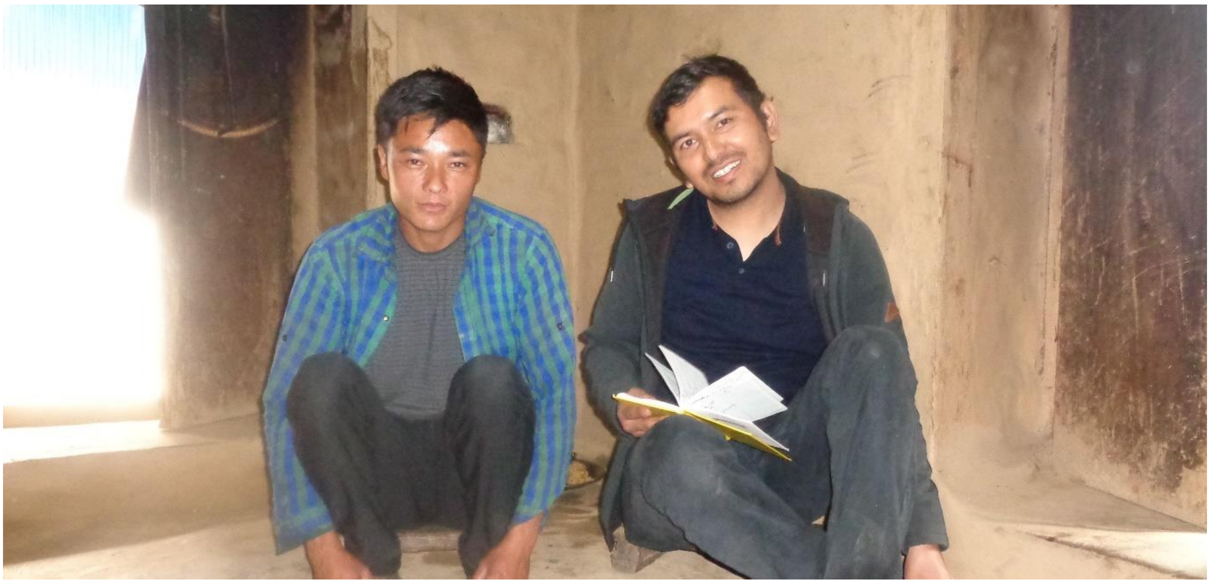

Figure 3.8: Photo with a local youth at the end of a conversation

Overall, despite the challenges imposed by the COVID-19 pandemic, I endeavoured to immerse myself as a participant observer (Bryman, 2004). I believe that the consistent reinforcement of my commitments to ensure confidentiality and anonymity in the research, accompanied with the sustained relationships, helped to diminish the ‘insider-outsider’ divide between myself and my research participants, allowing for data collection that is less influenced by participants’ preconception of me and my position or status (Merriam et al., 2001). Additionally, the adoption of a mixed methods approach of data collection helped me to ensure the consistency of information provided by my research participants.

3.3.4 Other ethical considerations

“It is the responsibility of the ethnographer to try to act in ways that are ethically appropriate, taking due account of his or her goals and values, the situation in which the research is being carried out, and the values and interests of the people involved.”

- Atkinson & Hammersley (2007, p. 228)

Right from the design phase of this research, significant effort was made to ensure appropriate ethical standards in all phases of my research. I have tried to give careful attention at avoiding any potential physical, mental or psycho-social harms that my participants might have to face by participating in my research (Banks & Scheyvens, 2014; Madge, 1997). Throughout my fieldwork and subsequent data analysis and thesis writing, I have respected the confidentiality and anonymity of the participants. I iteratively repeated the research objectives and limitations, and purpose of their participation. I also tried to ensure that by participating in my research activities, other household and everyday priorities were not compromised. Hence, for this, I clearly mentioned the anticipated time required, adopted a flexible approach to both postpone or incrementally conduct my research, and only proceeded with my participants' agreement.

The fieldwork overlapped with different waves of the COVID-19 pandemic, and to ensure the safety of both myself and my participants, I followed all COVID-19 safety measures recommended by national and international public health authorities, including the Ministry of Health and Population (MoHP) of Nepal and the World Health Organization (WHO). I regularly carried out antigen detection Rapid Diagnostic Test (RDT), constantly wore a facemask, maintained a minimum 2-meter distance, regularly used hand sanitizer, and organized group discussions mostly in open spaces and only when it was necessary to organize. Moreover, given the nature of this research which involved navigating narrow paths and fragile slopes for inspection and sensors installation or repair, comprehensive risk assessments and mitigation strategies were followed to minimize the exposure and risks to landslides.

Simultaneously, while engaging with individuals affected by landslides, I remained sensitive and showed empathy to the potential psychological stress which the participants were possibly experiencing. Maintaining a down-to-earth behaviour and simple dress, reflective of my overall personality, and respecting diverse opinions and cultural values were central aspects of my fieldwork. Because of the marginalized geographical and socio-economic status of many participants, some requested me to help them access the external resources for compensation of crop and property damage caused by road-triggered landslides. Similar expectations were experienced by Basyal (2021) in his research in the adjoining Upper Bhotekoshi Valley. In such circumstances, adhering to the advice of Sidaway (1992), I refrained from giving any false hopes or making false promises, and openly communicated the limitations of the research and myself.

To ensure the research brings some active benefits to the participants, a key principle advocated by Hicks et al. (2019) for people's engagement in multi-dimensional citizen science projects on DRR, I strategically framed the analysis of instrumental data collected through participatory landslide monitoring to align with local aspirations. Consequently, I have analysed the rainfall and its patterns, and tried to show how they cause changes in soil moisture and slope deformation as reflected in the acoustic emissions data. Additionally, in response to community concerns, I facilitated some group discussions to jointly explore potential resources, which led to a successful connection with a donor, who provided tarpaulins for the households who practiced seasonal relocation to safer areas during the monsoon. These tarpaulins were designated to construct temporary makeshift shelters.

Looking forward beyond my thesis, I plan to sustain engagement with policy makers, practitioners, and media professionals both formally through research sharing and presentations, and informally through casual conversations, to continually try to inspire them to become more responsive to local concerns and issues. These efforts may not yield direct or immediate benefits to the local participants but could bring many intangible benefits in future. Through fostering a shift in perspectives and encouraging a greater sense of accountability, I believe the issues and needs of many communities and households prone to or affected by small- to medium-scale landslides, like my study area, get the attention they rightfully deserve.

3.4 Epistemological stance and methods of data collection

This research is grounded in a pragmatist epistemology, emphasizing the interconnectedness of experience, knowledge, and actions, and prioritizing the co-production of actionable knowledge and practical solutions to issues of people's concerns related to landslides (Kelly & Cordeiro, 2020). Unlike the worldviews such as constructivism and post-positivism that focus on abstraction or philosophical theory-generation, the pragmatist approach aims to tackle real-world issues through actionable beliefs and practices (Morgan, 2014).

This research employs a plurality of data collection approaches, integrating both qualitative and quantitative methods from social and physical sciences to comprehensively understand the underlying causes of landslide vulnerability and the dynamic risk reduction knowledge of historically marginalized groups, often overlooked by 'outsiders' (Creswell, 2009; Creswell & Creswell, 2018; Dewey, 1929) (see Figure 3.9). Employing a variety of data collection methods helped to ensure the consistency of the collected data across sources (Flick, 2004; Perlesz & Lindsay, 2003). The data collection methodologies and methods are detailed in sub-sections 3.4.1, 3.4.2 and 3.4.3.

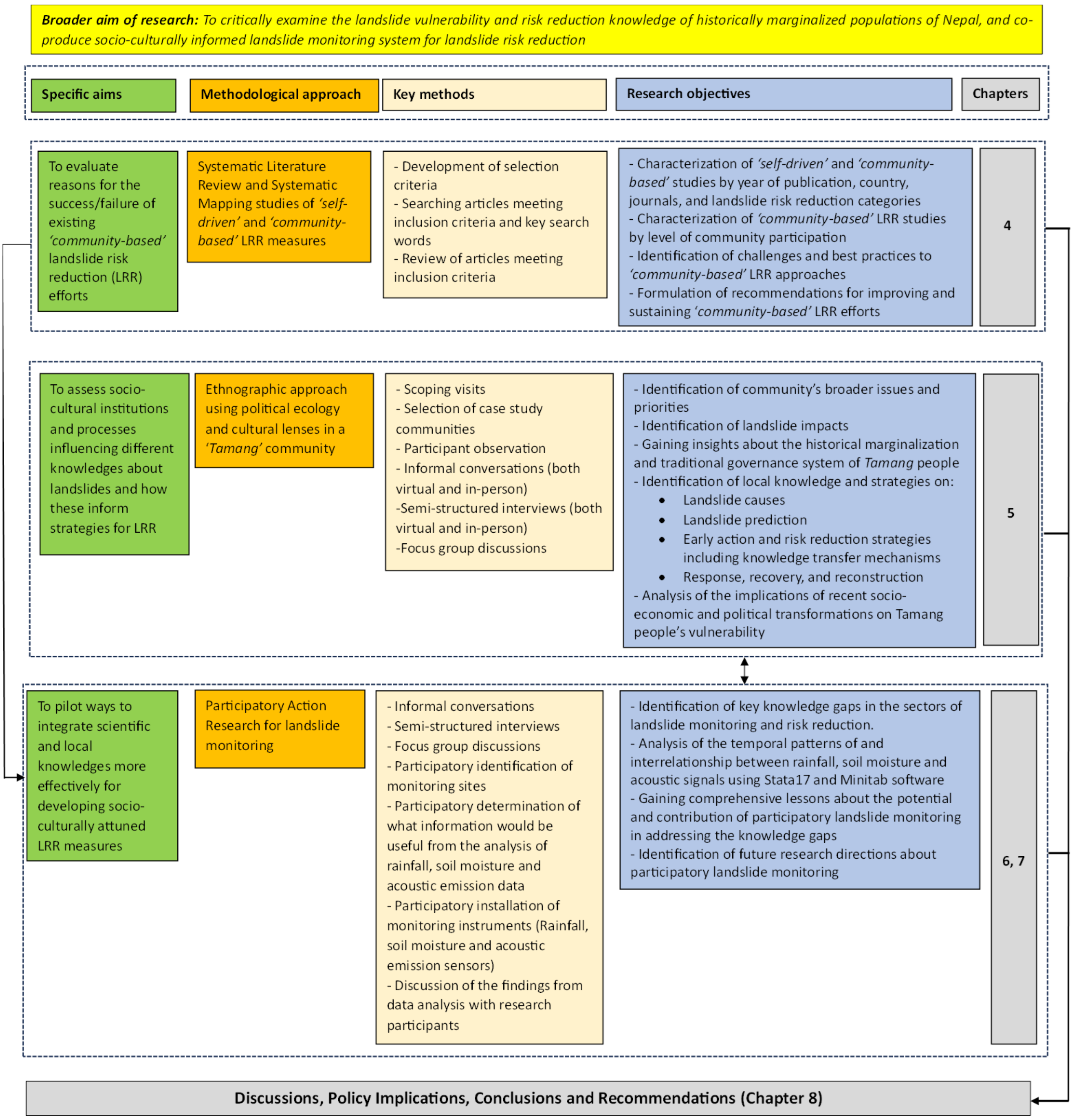

Figure 3.9: Schematic diagram summarizing methodological approach and data collection methods adopted in the research, illustrating their application to achieving key outputs and chapters

In addition, this research adopts a participatory/advocacy worldview collaborating 'with' research participants in knowledge co-production, rather than merely researching 'on' or 'about' them (Atkins, 2013; Charlton, 1998; Tanabe et al., 2018). To ensure the practical relevance, this research has given due attention to anchor participants' experiences and aspirations in research agendas, particularly within the participatory action research component aimed at co-developing landslide monitoring systems. By collaborating with participants in cycles of actions and reflections, this research aims to amplify their voices to planners, decision-makers, and relevant stakeholders.

3.4.1 Systematic literature review and mapping studies for assessing the successes and limitations of community-based landslide risk reduction efforts (Research Question 1)

Due to the COVID-19 pandemic, I adjusted my research focus to incorporate a component exploring the successes and failures of previous Community-based Landslide Risk Reduction (CBLRR) efforts based on a retrospective review of literature. For this, I analysed the peer-reviewed and grey literature on CBLRR measures undertaken in different parts of the world. Relevant literature was identified through databases such as Web of Science and Scopus using key search terms and inclusion criteria developed by considering their potential relevance to remaining two research questions. The detailed methodology followed for this research component is provided in Chapter 4.

3.4.2 Online and in-person ethnographic methods for assessing the socio-cultural institutions and processes influencing different local knowledges and strategies (Research Question 2)

My first period of data collection for Research Questions 2 and 3 involved virtual data collection methods using online platforms such as Facebook Messenger, WhatsApp, Viber, Zoom, Microsoft Teams, and Skype. This was done during the first wave of the COVID-19 pandemic while I was in UK when the planned onsite fieldwork had to be paused. As mentioned above, I adjusted the research focus and utilized the initial periods of pandemic-triggered lockdown and 'working from home' (Pradhan et al., 2021; Ritchie et al., 2024) to review studies on CBLRR, assessing the reasons for successes and failures. The findings of this study are presented in Chapter 4.

In the later stages of the first wave of the COVID-19 pandemic from November 2020 onwards, I began exploring virtual data collection opportunities (Lupton, 2021). I conducted semi-structured online interviews with 18 DRR authorities, practitioners and researchers working in Nepal. For this, I leveraged the professional networks developed while working in NGO sector and gradually expanded following referrals[6]. Additionally, using contacts established during my scoping visits in December 2019 to January 2020, I started engaging in informal conversations with some local inhabitants of my study area.

Upon the easing of travel restrictions imposed by both Durham University and the governments of Nepal and the UK after the first wave of COVID-19, I travelled to Nepal in April 2021—a year later than originally planned—to commence my fieldwork. However, I could not start my fieldwork until second week of May 2021 due to the post-international travel-related self-isolation mandate and a new lockdown imposed by the Nepalese government in response to the second wave of COVID-19, characterized by the 'Delta' variant.

My initial engagements in the field were conducted with limited number of local participants, adhering to COVID-19 safety protocols. Gradually, I started collecting data in an iterative fashion (Burawoy, 1998) through participant observation, informal conversations, and semi-structured ethnographic interviews/focus group discussions (Bryman, 2004; Hammersley & Atkinson, 2019). I remained on fieldwork until October 2022, but continued to be in touch with my participants through virtual means and periodic visits to the villages thereafter.

The ethnographic methods applied in the field are explained in subsequent sub-sections below. At first glance, it may seem difficult to differentiate the tools used in this study for data collection from the trademark participatory rural appraisal (PRA) tools applied by development practitioners, but the distinction lies in the preceding efforts to build relationships, understand context, and identify the right participants. I maintained open-endedness and flexibility throughout my research and data collection process. This set my research methods and approach apart from the quickly undertaken participatory appraisal

[6] I had worked for around eight years with different national and international NGOs in disaster risk reduction sector, and the links established during those years were valuable in approaching authorities, practitioners and researchers for participating in my research.

and learning methods that often proceed by framing problems based on abstract but available solutions (Oven et al., 2019).

3.4.2.1 Participant observation and informal conversations

In this study, I used participant observation in conjunction with informal conversations (Kawulich, 2005; Swain & King, 2022) as key strategies for both building trust and collecting data. At Mathillo Sigarche, with Tamang residents, I tried to actively immerse myself in the household and broader group activities. These involved holding informal conversations while people were ploughing fields, grazing cattle, guarding crops against monkeys, planting millet, or constructing stone walls to reinforce their fields. Valuable insights were also gained through participating in informal chats around the hearth during cooking time and, notably, by respectfully opting for tea instead of *Airak*[7] (home-brewed alcohol). Upon receiving permission, I made note of the crucial discussion points. Additionally, some conversations were recorded and promptly transferred to the password protected laptop for security. Anonymity of the informants was ensured while documenting or transcribing the conversations. Local people also showed me fields and houses affected by landslides. These immersive experiences provided me with the deep insights about people's everyday lives, experiences, priorities, perception of risks, past landslide impacts and coping strategies, beliefs, and cultural practices, ultimately yielding valuable information that significantly enriched my research.

3.4.2.2 Semi-structured interviews

I engaged in semi-structured interviews with a diverse group of 79 respondents[8] encompassing residents, elected local representatives, DRR authorities working at local,

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[7] Tamang word for locally brewed alcohol

[8] Eight of the local respondents are from Tallo Sigarche with whom the interviews were focused around landslide history, impacts and risk reduction measures and views around participatory landslide monitoring system setting up the context for participatory landslide monitoring. This contrasts with approach followed in Mathillo Sigarche where more broader issues with greater depths were explored involving greater number of participants. Hence, Chapter 5 analyses the findings for Mathillo Sigarche only whereas Chapters 6 and 7 involve the analysis of observation, discussion, and interviews with informants from both Mathillo Sigarche and Tallo Sigarche.

district and federal levels, researchers and practitioners working in the sector of landslide risk reduction or with Tamang community (see Table 3.1 below). When feasible, follow-up interviews were done with respondents' agreement to explore different topics or to delve deeper into previously discussed ideas. This approach was implemented with the majority of participants. The initial interviews were conducted virtually due to the pandemic. However, as COVID-19 cases started to decline, face-to-face interviews were conducted.

A preliminary interview checklist was prepared (Appendix 4) that featured open-ended questions to give the flexibility to move between themes, or questions based on the interview flow and respondent's previous responses. The choice of topics also varied according to the background of interviewee. Prior to the start of each interview, verbal consent was taken, and respondents were informed about the voluntary nature and anticipated duration of interview. To make interviewee feel as comfortable as possible, I adopted an informal to semi-formal approach, with exceptions for some interactions involving government officials, local representatives and some DRR practitioners and academics. In some interviews, the main respondent was accompanied by his/her colleague or family members. Each interview ranged from 45 to 90 minutes.

The village level respondents were chosen after spending some time in the study area, enabling me to have a stronger rapport with villagers and a better understanding of relevant informants. Overall, the semi-structured interviews with local inhabitants and local-to-national stakeholders aimed at acquiring in-depth insights into various topics and wider issues, such as existing policy and institutional frameworks on Landslide Risk Reduction (LRR); government plans and involvements in LRR; gaps and key challenges for LRR; available and potential landslide monitoring and early warning systems; local contexts and livelihoods; local priorities and concerns; local experiences and perceptions of landslides; indigenous knowledge for LRR; and local culture and governance systems. In my experience, these interviews played a pivotal role in both comparing and complementing the information collected through other data collection methods.

Table 3.1: Background of different interviewees of semi-structured interview

Background of different respondents of semi-structured interview	Number of interviewees
Residents (landslide affected people, *Lama*, *Bombo*, local teachers, local auxiliary nurse-midwives, local social workers, members of school management committee, local youths, community forest representative)	22
National level government officials (Representatives from line ministries and departments)	8
District level government officials (DAO, DCC, DEOC, NRA's District Grant Management and Local Infrastructure Project Implementation Unit)	6
Local elected representatives (Mayor, Deputy mayor, ward chairperson, ward members)	6
Local level government officials (DRR focal persons, LEOC staff)	4
Researchers/academics	5
DRR practitioners (NGO/INGO/Red Cross/UN agencies workers) at National level	17
DRR practitioners (NGO/INGO/Red Cross workers) at district and local levels	9
Private sector involved in developing and marketing sensors and technologies for hazards monitoring and early warning	2

3.4.2.3 Focus group discussions

Due to the overlap of my fieldwork with different waves of COVID-19, I had to limit the number of Focus Group Discussions (FGDs). Consequently, the introduction and sharing of my research goals, objectives and approach were conducted in one-to-one meetings or in smaller groups within neighbourhoods. As the pandemic situation improved and restrictions were eased, and especially after the widespread promotion of COVID-19 vaccinations, I gradually started conducting FGDs to capture shared narratives and to complement data from other methods.

In Mathillo Sigarche, the first FGD took place in the third week of October 2021, nearly five months into my onsite field work. The first session involved seven purposively selected residents (4 male and 3 female) who had been affected by landslides in the past. I ensured strict adherence to COVID-19 safety measures including the meeting conduction in an open space, maintaining a minimum 2-meter physical distance, and ensuring all participants including myself wore facemasks throughout.

However, limiting the participation to a smaller number was challenging as other neighbouring villagers frequently visited, driven by curiosity. In such circumstances, I politely clarified the purpose of the meeting and emphasized the importance of restricting participants' numbers for health and safety reasons. Furthermore, I pledged to revisit them in future to discuss the topic. Persuading people was difficult, and in my view, many underestimated the risks of COVID-19. Nevertheless, I, with the help of other local participants, convinced people to adhere to our health safety requests. This experience led me to prioritize one-to-one meetings and conversations for health safety reasons, and to organize group meetings only when deemed necessary or important.

Of the seven participants of the first FGD, six belonged to families that had chosen temporary relocation during previous years' monsoons. For this, they set-up makeshift shelters in nearby public area where they felt safer compared to their houses. The first meeting lasted for around 90 minutes and was centred on general issues, local livelihoods, major local festivals and rituals, past landslide incidences, and impacts.

Seven more group discussions were conducted in Mathillo Sigarche throughout the study[9]. The discussions covered range of topics such as perceived causes of landslides, local strategies (both religious and non-religious) for reducing and predicting landslide risks, and what government and non-government organizations are doing or have done in the village to reduce landslide risks. Of these, one discussion was conducted with exclusively female and then another with solely male participants, while the others were mixed. The participant numbers ranged from 7 to 12, and the topics were revisited when meetings were held with participants from different sub-settlements within Mathillo Sigarche.

For all focus groups, the proposed discussion topics, time, and venue were communicated and agreed in advance to minimize the chances of conflicting expectations and commitments. Meetings were also rescheduled if they coincided with their other priorities. Facilitation skills played a crucial role in ensuring every participant had a voice. This also required a close observation of the vocal and silent participants and trying ways to motivate more silent

[9] The focus group discussion meetings for participatory landslide monitoring are counted separately under section 3.4.3.

participants to speak. When people felt comfortable expressing themselves in their mother tongue, *Tamang*, they were encouraged to do so. In such instances, my research assistant and other participants assisted in translating.

In Tallo Sigarche, the informal conversations (presented in section 3.4.2.1 above), semi-structured interviews (presented in section 3.4.2.2 above) and the FGDs were specifically confined to participants from the school management committee and residents living near to the local primary school where the participatory landslide monitoring was to take place. These strategies of discussion and data collection in Tallo Sigarche were centred directly on topics related to history and impacts of landslide at the proposed site, past and ongoing risk reduction efforts, and making plans for proposed monitoring. This stands in contrast to the more comprehensive exploration of the broader issues, as well as deeper socio-cultural and historical root causes undertaken in Mathillo Sigarche involving a larger number of people. As explained earlier, the reason behind following differential levels and purpose of engagement with local people across two research sites stemmed primarily from the impacts of COVID-19 pandemic on my research. Consequently, the analysis presented in Chapter 5 involves the interpretation of the socio-cultural institutions and processes that shape local knowledge and strategies of historically marginalized Tamang people (Tamang, 1992) from Mathillo Sigarche and excludes interpretation for relatively affluent Chhetris, Newars and Brahmins (CDA, 2020b). However, Chapters 6 and 7, which explore the participatory landslide monitoring, interprets the findings for both Mathillo Sigarche and Tallo Sigarche.

The methodological approach followed for data collection in the context of participatory landslide monitoring (Chapters 6 and 7) is presented in Section 3.4.3 below.

3.4.3 Combining ethnographic and natural science methods for participatory landslide monitoring (Research Question 3)

The ethnographic approaches outlined in 3.4.2 not only facilitated the collection of data for Chapter 5, but also setup the context for participatory landslide monitoring presented in Chapters 6 and 7. Additional focused conversations and group discussions were held to underpin the landslide monitoring component of my research. While maintaining continuous interactions with local inhabitants in both Tallo Sigarche and Mathillo Sigarche informally and through semi-structured interviews, the inaugural interactive group meeting with participants aimed at setting up the landslide monitoring was held in first week of January 2022 in Tallo Sigarche. This meeting lasted for approximately 2 hours and during that meeting, I shared the preliminary findings from my review of community-based landslide risk reduction measures (Chapter 4). I also presented different site-specific and regional landslide forecast and monitoring mechanisms implemented globally and in Nepal, including the 3-day weather forecast and daily disaster bulletins disseminated by the Nepal government through Facebook and official websites. This meeting provided the opportunity to capture perceptions of the utility of such government advisories. In general, while the advisories were considered useful for prompting general precautionary measures, their lack of temporal and spatial specificity rendered them vague and unhelpful in my field sites.

A similar discussion planned for Mathillo Sigarche had to be delayed until the second week of February 2022 due to my positive COVID-19 test result in second week of January. This unforeseen circumstance kept me away from the research sites for almost two weeks. Following these initial meetings, eight additional sessions—four each in Mathillo Sigarche and Tallo Sigarche—were held from March 2022 through April 2022. These meetings focused on discussions about the proposed landslide monitoring instruments and parameters, potential sites for landslide monitoring, the type of information deemed useful by the participants, and the division of roles in the process. The processes followed and the discussions held during these meetings are detailed in sections 6.4 and 6.5 of Chapter 6.

Alongside these mixed qualitative methods, Chapters 6 and 7 also incorporate the natural science methods of data collection, involving the data collected by temperature, soil moisture, rainfall, and acoustic emission sensors. The processes and discussions that shaped the establishment of participatory landslide monitoring (Chapter 6) and the subsequent analysis of the monitored data (Chapter 7) followed the eleven months of prior ethnographic work (Chapter 5). This is why the procedures followed for setting up the participatory landslide monitoring are comprehensively explained in Chapter 6, following the presentation of findings from my ethnographic work in Chapter 5. I believe this approach allows readers to better follow the chronological progression of my fieldwork activities, data collection strategies, and findings.

3.5 Data analysis

3.5.1 Analysis of data collected through informal conversations, semi-structured interviews and focus group discussions

As highlighted by Jackson (2001) and Crang & Cook (2007), the analysis of qualitative data can be a time-consuming and messy process. The field notes, interview transcripts and audio-records were first transcribed into text in Microsoft word. Although this was a lengthy process, this gave me a sense of emerging themes and sub-themes. This was followed by categorizing this information into different themes and sub-themes using NVivo 12 software[10] (Lumivero, 2017) for giving appropriate codes and sub-codes to different themes and sub-themes. This involved re-reading transcripts and primary materials to understand the meaning and intent of information, understand interconnections between the different themes, and interpret the wider emerging issues (Creswell, 2009). For this, I developed, assigned and reassigned appropriate codes to different themes and sub-themes following the 'grounded theory' approach (Crang & Cook, 2007). With constant revision, I explored the connections between themes (ibid).

Overall, the process of qualitative data analysis was not linear. Instead, it was an ongoing process concurrent with data collection, transcription, coding, interpretation, and even through to the time of thesis writing (Creswell & Creswell, 2018).

3.5.2 Analysis of instrumental data collected by weather and acoustic emission sensors

The data collected by the weather and acoustic emission sensors, encompassing rainfall, temperature, soil moisture and acoustic emission parameters, were analysed using Stata17 (StataCorp LLC, 2021) and Minitab software (Minitab LLC, 2021). The analyses were shaped by the insights from my research participants, who provided valuable suggestions on what they considered suitable for their needs and contexts. The cross-correlation function (CCF) analysis to examine the time-lags between rainfall events and soil moisture was undertaken using Minitab. Likewise, other analyses, such as the total, monsoonal, weekly, daily, and hourly

[10] NVivo is a software for organizing, analysing, and visualizing qualitative data. See About NVivo (qsrinternational.com)

patterns of rainfall, soil moisture, and acoustic emissions, and interpretation of the relationship between them were conducted using Stata 17 as described in Chapter 7.

3.6 Sharing findings with communities and stakeholders

Following the recommendation of Banks & Scheyvens (2014) to reciprocate the generosity of those who gave their time, knowledge and support in the research, I visited the research sites in June 2023 to share preliminary findings of my study. However, participant availability was limited due to people's busy schedules in preparing fields for millet and paddy plantation. Consequently, I opted to create a video presentation for sharing online, highlighting key findings derived from the analysis of the data available so far including rainfall, soil moisture, temperature, and acoustic emissions data. This video was then uploaded on Youtube (Shrestha, 2023) and the link was shared with the research participants via Facebook messenger, WhatsApp, and Viber. After the detailed analyses, I made another visit to the research sites in March 2024 to disseminate further findings (see Figure 3.10).

Besides these, research findings presented in Chapter 4 were shared with the research participants while setting up the context for participatory landslide monitoring process. Research findings presented in Chapter 5 were virtually presented at the 19th Nepal Study Days, organized by Britain-Nepal Academic Council (BNAC) at the Institute of Social and Cultural Anthropology (ISCA) of the University of Oxford on 13-14 April 2022. Extending beyond my thesis submission, I am committed to the continued dissemination of research findings through publications and presentations in different forums. I aspire to influence researchers, policy makers, authorities, media, and practitioners for a greater public benefit.

Figure 3.10: Glimpses of discussion during final sharing meeting at Tallo Sigarche in March 2024

3.7 Reflections on the research process and compromise: doing fieldwork in a pandemic

Conducting fieldwork during the COVID-19 pandemic presented uncertainties, challenges, and repeated adjustments. My onsite fieldwork commenced only in May 2021, delayed by more than a year. Like the experiences of many, adapting to the 'lockdown' lifestyle was initially challenging, particularly as the COVID-19 cases and deaths surged in both the UK and in Nepal. I was concerned for my well-being and that of my parents and other family members in Nepal.

My concerns for my family in Nepal heightened when the then Prime Minister of Nepal publicly downplayed the pandemic (Pandey, 2020; Tamang, 2020). Consequently, the earlier weeks of 'stay-at-home' mandates involved regular communication with family, friends, and relatives back in Nepal to share updates and experiences, and to ensure everyone were adhering to proper safety strategies. My experience mirrors the narratives of many others, wonderfully presented by Ritchie et al. (2024) in their study, about the impacts of pandemic on hazard and disaster researchers.

With time, I became accustomed to 'working from home' which had evolved into a 'new normal' during the pandemic (Corpuz, 2021). This was significantly supported through the moral support of my supervisors and the GCRF-CDT administration[11]. The University's health and safety services facilitated the setup of a workstation at home by dispatching an office chair.

Gradually, drawing from the insights of Hine (2008, 2017), I incorporated the virtual modes of ethnography to strengthen my connections with research participants and progressively collect data through informal online conversations and semi-structured interviews. As the pandemic exhibited signs of improvement, I travelled to Nepal in April 2021 for on-the-ground fieldwork with yet another revised plan and timeline. This time, in consultation with my supervisors, I aimed to undertake an immersive and relatively 'unscripted' ethnography (O'Neill, 2012) at Mathillo Sigarche, focusing the historically marginalized Tamang groups to address both research questions 2 and 3 (Chapters 5-7). Simultaneously, I planned to implement 'purposive fieldwork activities' (ibid), concentrating on research question 3

[11] GCRF-CDT is the abbreviation for Durham University's Global Challenges Research Fund-Centre for Doctoral Training that funded this interdisciplinary research and research of 24 other international PhD students.

exclusively at Tallo Sigarche. This specific focus involved co-generating new ways and knowledge of landslide monitoring at Mathillo Sigarche and Tallo Sigarche (Chapters 6 and 7).

Nevertheless, this revised plan and timeline for my thesis faced further disruptions due to the emergence of new variants, causing subsequent lockdowns and/or safety protocols. In response, I limited the number of FGDs and instead opted for one-to-one conversations and semi-structured interviews which were easier to conduct safely. I had planned to rent a room within one of two study areas, but there was no better access to Personal Protection Equipment (PPE). Additionally, I anticipated it will be practically impossible and rude in forcing individuals in the village to wear facemasks while approaching or talking to me. Hence, reflecting my personal health safety concerns, I opted to rent a room at Barhabise Bazaar, nearly a two-hour walk from the village, where the improved access to PPE and better health facilities offered a safety advantage. I acknowledge that this decision might have affected people's perception of my positionality, and under normal circumstances, I would not have opted for it. However, I tried to mitigate this by frequently visiting the field, up to three times a week and spending extended hours in field during those visits. Additionally, I made frequent phone calls to maintain connection with people, and frequently stayed in local residents' houses when the incidences and risks of COVID-19 had comparatively decreased.

Despite these safety precautions, I found situations when I had to self-quarantine due to the accidental exposure with symptomatic individuals. I also had to undertake self-isolation when I contracted the virus. I did not encounter major health complications while I was COVID-19 positive, but I did have a persistent dry cough afterwards. This condition endured for about a month until I visited a doctor in Kathmandu and took prescribed antibiotics.

The COVID-19 pandemic led to a delay in arrival of essential equipment for landslide monitoring into Nepal, specifically the Hobo loggers and the Acoustic Emission (AE) sensors. Both the AE sensors and Hobo loggers had to be dispatched from the UK, but the manufacturers faced constraints in their manufacturing and dispatching capabilities due to the pandemic, resulting in the later-than-expected delivery. Consequently, the sensors installation was completed only in the second week of September 2022, a period corresponding to the later stages of monsoon. In 2022, it did not rain much after the landslide monitoring equipment installation. This meant I missed out the opportunity to interpret the relationship between rainfall, soil moisture and slope movement which was a crucial aspect of my research. In response, I, in consultation with my supervisors, decided to use the instrumental data from June-September 2023 for my analysis, to inform Chapters 6 and 7. This necessitated the extension of the thesis timeline.

The cumulative impact of these circumstances significantly affected the progress and duration of my analysis and thesis writing. The delay in installation affected other aspects too. For instance, my original plans were to closely discuss the instrumental data with my research participants on near real-time basis to assess the consistency between this data and people's observations or perceptions. However, due to my return to the UK in October 2022— approximately a month after the sensor installation to focus on qualitative data analysis that informs Chapter 5 and 6, I assessed if the instrumental data reinforced, contradicted, or altered their perceptions of weather and slope instability status primarily during my final sharing meeting conducted in March 2024.

Thus, undertaking fieldwork during the COVID-19 pandemic was a tumultuous journey marked by a rollercoaster of emotions, experience, and amendments. I had to continually adjust my research in response to the evolving situation. Likewise, it is also important to note that this thesis deliberately excludes a significant amount of information collected from the field because not all information from the field logically fitted in the central argument that this thesis tries to make. The exclusion of this information is not an indication of information's lack of importance, but rather reflects a practical decision made to align within the framework and limitations of the thesis.

Chapter 4 A critical review of the successes and failures of community-based landslide risk reduction measures

4.1 Introduction

Landslides are one of the most destructive geophysical hazards that annually cause significant human and property losses worldwide (Gnyawali et al., 2023; Oven, 2009). According to the EM-DAT database, landslides caused over 9000 fatalities globally during 2006-2015 (IFRC, 2016). The actual losses could surpass the reported figures as the impacts of many small to medium scale landslides that occur in remote areas and kill less than five people often go unreported or are attributed to primary hazards (for example, an earthquake rather than a co-seismic landslide) (Froude & Petley, 2018; Oven, 2009; Oven et al., 2021).

Asia accounts for the highest number of reported fatal landslide occurrences and associated deaths (IFRC, 2016) accounting for 75% of reported global fatal landslides events during 2004 to 2016 (Froude & Petley, 2018). Within Asia, the Himalayan region stands out as the most landslide-prone areas due to rugged topography, unstable geological structures, soft and fragile rocks, heavy and concentrated rainfalls, climate change impacts, 'ribbon sprawl' development patterns, and other socio-economic and anthropogenic factors (Bhandari, 2008; Chae et al., 2017; Dahal, 2012; Rusk et al., 2022).

Addressing landslide risk, particularly in areas where landslide hazard is chronic and resources for mitigation are limited, often involves community-based landslide risk reduction (CBLRR). Nevertheless, compared to measures targeting other hazards such as floods and hurricanes, knowledge and expertise about CBLRR measures are often limited (Oven et al., 2017). Common CBLRR measures involve the construction of relatively small-scale gabion walls, bioengineering, and drainage, although the effectiveness of these measures remains questionable in actually reducing the landslide risks in diverse physical and social environments (ibid). Therefore, it is crucial to learn from broader experiences of implementing

CBLRR measures (Maes et al., 2017). However, there is a scarcity of comprehensive reviews on the topic.

This chapter aims to bridge the gaps in the sector by conducting the retrospective review of CBLRR studies. For this, I have analysed the peer-reviewed and grey literature on CBLRR measures to understand how community-based approaches are and could be applied to reduce landslide risks, with a particular focus on Nepal. Additionally, the literature on 'self-driven' household and community approaches to Landslide Risk Reduction (LRR) have also been reviewed to compare community and household actions undertaken with and without external support. For easy comparison and differentiation between the two approaches, throughout this chapter and successive chapters, the actions undertaken by households and communities without the support of 'outsiders'—the external disaster-related organizations, professionals or researchers working in communities or what Lane et al. (2011) called 'certified' scientists are referred to as 'self-driven' approaches. Conversely, 'CBLRR' denotes the measures taken by/in communities with the support of external agencies, 'certified' experts, or individuals. This chapter also evaluates the forms and levels of participation in different CBLRR measures implemented worldwide using Dyball et al. (2007)'s categorization of participation levels (see Table 4.1). The insights gained from this review are intended to be useful for implementing CBLRR measures in landslide-prone areas of the world.

This chapter comprises five main sections. The introduction section (Section 4.1) provides an overview of landslide risk. Additionally, it has three subsections: landslide risk context in Nepal (4.1.1), community-based approaches to LRR (4.1.2) and people's participation in community-based landslide risk reduction efforts (4.1.3). The introduction section and its subsections are followed by the description of methodology (Section 4.2). Subsequently, the chapter presents the findings of the review (Section 4.3) and engages in discussion (Section 4.4). Finally, the chapter concludes (Section 4.5) with summarizing conclusions, recommendations and policy implications drawn from the review.

For this chapter, the literature on self-driven and CBLRR measures were mapped and reviewed using academic databases such as Web of Science and Scopus. Additional articles and publications prepared in Nepali language and the ones prepared by relevant government offices and departments, I/NGOs and UN agencies about the CBLRR measures implemented in Nepal but not published in peer-reviewed journals were also studied. Special attention was devoted to Nepal-based studies to garner deeper insights into the strategies and obstacles surrounding CBLRR measures in the contexts of developing countries.

4.1.1 Landslide risk context in Nepal

Nepal accounted for 10% of global reported rainfall-triggered fatal landslide events from 2004 to 2016 (Froude & Petley, 2018). The focus of landslide impacts is controlled by the south Asian monsoon, where for example, between 14th April 2020 and 28th August 2020, Nepal experienced multiple landslides that resulted in 296 fatalities and 64 people missing (MoHA, 2020). Despite undergoing significant socio-economic and political transformations (Oven et al., 2021), Nepal is ranked 143rd out of 191 countries according to the 2021's Human Development Index (HDI) (UNDP, 2022). Notable transformations include increasing reliance on a remittance-based economy (Campbell, 2018), a new constitution, state restructuring and local level elections after almost two decades (Bownas & Bishokarma, 2019; Hutt, 2020), a substantial increase in the number of mobile phone and internet users (MoCIT, 2018), and a surge in haphazard rural road construction (Sudmeier-Rieux et al., 2019) and roadside migration (McAdoo et al., 2018). These changes not only provide the context within which landslide disasters are experienced, but also at times are seen to exacerbate the impacts of landslides as and when they occur.

4.1.2 Community-based approaches to landslide risk reduction

The scientific literature highlights two primary approaches to disaster/landslide risk reduction: top-down and technocratic, and bottom-up and people-centred approaches. The top-down approaches are typically hierarchical, often deployed by government organizations and/or scientific institutions (Gaillard, 2022a). Such approaches emphasize technical solutions (Oliver-Smith, 2016; Tarchiani et al., 2020), with the public positioned as passive recipients of information on risk assessment, preparedness measures, hazard alerts and emergency plans (Scolobig et al., 2015). While these approaches can bring some tangible benefits to the communities, they are frequently criticized for being disconnected from local contexts and for failing to address the underlying causes of vulnerabilities (Anderson et al., 2014; Baudoin et al., 2016; Maskrey, 2011; Oven et al., 2019). Moreover, they are often considered as inadequate in reducing fatalities and socio-economic impacts from natural hazards (Raška, 2019), particularly in developing countries and urban poor areas where the traditional risk governance mechanisms are less formal (Scolobig et al., 2015).

In response to the limitations of the conventional top-down and technocratic approaches, Community-Based Disaster Risk Reduction/ Management (CBDRR/M) has emerged as a viable alternative (Delima et al., 2021; Scolobig et al., 2015). There is growing advocacy for meaningful participation of vulnerable and affected populations in DRR efforts (Gaillard & Mercer, 2012; Melis & Hilhorst, 2020). Particularly since the 1970s, CBDRR/M approaches have gained increasing popularity in both scientific and development sectors, offering a bottom-up strategy to reduce vulnerabilities and strengthen local-level capacities to address disaster risks and impacts (Klein et al., 2019; Ruiz-Cortés & Alcántara-Ayala, 2020).

In theory, Community-Based Disaster Risk Management (CBDRM) is not only about implementing risk reduction activities at a community level but is also about "empowering communities to change roles from objects to subjects in a very dynamic process of vulnerability reduction, enabling them to negotiate resources and support from local and central governments to undertake risk management measures at all scales" (Maskrey, 2011, p. 4). Abarquez & Murshed (2004) described CBDRM as a "process of disaster risk management in which at-risk communities are actively engaged in the identification, analysis, treatment, monitoring, and evaluation of disaster risks to reduce their vulnerabilities and enhance their capacities" (p. 9). However, in practice, CBDRM projects may not involve genuine community participation, ownership, and empowerment, but as highlighted by IFRC (2012) and Macherera & Chimbari (2016) in the case of community-based early warning systems, may denote the projects that are based at community-level but are designed and implemented by external agencies.

It is commonly taken for granted that the CBDRR/M measures are the most effective means to incorporate local knowledge and empower communities, but in practice, this may not always be the case (Šakić Trogrlić et al., 2022). Most of the CBDRR/M projects, including those focused on LRR, incorporate the Participatory Vulnerability Capacity Assessment (PVCA) process to comprehend the nature, causes and potential impacts of risks faced by communities, identify existing capacities available at different levels to reduce the risks, and assess actions that can be taken to increase capacity and reduce the risks (Liu et al., 2018). However, although seemingly participatory and bottom-up at a first glance, the PVCA process is not necessarily effective in identifying and addressing the root causes of disaster vulnerabilities (IFRC, 2014; Oven et al., 2017). Facilitated mostly by outsiders, such as the NGO workers who may not have a sufficient understanding of the diverse community needs, local cultural practices, power structures, and issues (Mosse, 1995), the four to five days spent on the PVCA process is insufficient to understand the complexities of power dynamics and gender contexts (Oven et al., 2017). Furthermore, such processes are criticized for prioritizing the predetermined hazard and available solutions based on the capacities and expertise of supporting agencies, rather than the genuine needs and priorities of those at risk (IFRC, 2014; Li, 2007, 2016; Oven et al., 2019). Consequently, community-based projects based on such PVCAs may reinforce, instead of challenging, pre-existing power structures, social hierarchies, and the underlying causes of vulnerability (Nagoda & Nightingale, 2017; Nightingale, 2005).

Beyond these limitations, the CBDRM/R sector face numerous other challenges, such as the macro-level origins of risks and vulnerabilities, financial and human resource constraints of supporting NGOs and government institutions, a donor funding landscape that favours technological solutions and short project timelines, as well as a disconnect between CBDRR/M efforts, risk producers, and government planning (Clark-Ginsberg, 2021; Šakić Trogrlić et al., 2022). These factors raise serious questions about the efficacy and effectiveness of the CBDRR/M initiatives.

This chapter, therefore, seeks to critically review the studies on 'self-driven' and 'community-based' landslide risk reduction measures, drawing lessons on both the limitations and best practices of these approaches, which could inform the design and implementation of future CBLRR initiatives.

4.1.3 People's participation in community-based landslide risk reduction projects

People's participation is an important aspect of community-based programs. Effective participation is believed to generate greater trust, legitimacy, ownership and governance, and speed-up the decision-making in DRR efforts (Lempert et al., 2023; Marchezini et al., 2018; Whitman et al., 2015). However, public participation, if handled improperly, can result in conflict, mistrust, and delay, mostly caused by selection bias, representativeness of the participants, financial, institutional, and time-related barriers, and power and resource inequalities between the participants (Scolobig et al., 2016; Tseng & Penning-Rowsell, 2012). In many cases, participatory programs disproportionately benefit the already powerful, and might merely be used as a tool of hegemonic compliance (Cooke & Kothari, 2001) or as the avenues for exercise of power and imposition (Campbell, 2005). Consequently, seemingly participatory and bottom-up actions might entrench the pre-existing power relations and cause further deprivation of marginalized groups and households (Cooke & Kothari, 2001; Nightingale, 2005, 2017).

4.1.3.1 Types of participation

Participation is a highly contested term with no consensus on its methods and objectives in research and development endeavours (Whitman et al., 2015). CBDRM projects involve a wide range of styles and levels of people's engagement. Various researchers have attempted to describe and categorize participation types and levels in different ways. For instance, Callon (1999) outlined three categories of participation in science and technology—the Public Education Model (PEM), Public Debate Model (PDM), and Co-production of Knowledge Model (CKM). According to Callon's PEM, scientific knowledge is distinct from lay knowledge, and a scientist's role is to teach the public and implicitly have nothing to learn from the public. In PEM, the public authorities act as intermediaries between scientific institutions and the public. The PDM establishes an environment for the public to negotiate on themes of general interest, and hence, the usual boundaries between scientists and laypeople are muddled (Callon, 1999). However, even then, PDM positions scientists as having adequate information compared to the public and hence, PDM-type engagements deny laypeople an active role in knowledge production (Lane et al., 2011). Participations are solely used to enrich scientific expertise (Callon, 1999).

CKM challenges the superiority of science and scientific knowledge by emphasizing that science and scientific knowledge alone is insufficient to generate new knowledge (Lane et al., 2011). Callon's CKM model considers the expertise is widely distributed within society and argues that laypeople also have competencies to mutually reinforce scientific knowledge and co-produce knowledge for the common good. In this model, people directly engage in the knowledge generation process with scientists and in certain circumstances, may lead the knowledge production, orientation, and evaluation (Callon, 1999).

Similarly, Arnstein (1969)'s ladder of citizen participation illustrated the continuum of participation forms from 'non-participation' to 'citizen control' where citizens take most of the decisions in community-based programs. Likewise, Dyball et al. (2007) underpinned participation as a key strand of social learning and highlighted that participation can range from coercion (passive participation) to co-acting (active participation) (see Table 4.1).

Table 4.1: Types of participation (Adapted from Dyball et al., 2007, p. 189*)*

Types of participation	Power relationships
Coercing	The will of one group is effectively imposed upon the other
Informing	Information is transferred in a one-way flow
Consulting	Information is sought from different groups, but one group (often the government) decides on the best course of action
Enticing	Groups jointly consider priority issues, but one group maintains power by enticing other groups to act through incentives (such as grants)
Co-creating	Participants share their knowledge to create new understandings and define roles and responsibilities, within existing institutional and social constraints
Co-acting	All participants set their agendas and negotiate ways to carry it out collaboratively. Power tends to shift between participants depending on the actions negotiated

In this study, Dyball et al.'s categorization was employed to analyse the levels of participation levels across different CBLRR measures implemented globally.

4.2 Methodology

A literature review of self-driven and community-based approaches to LRR was conducted following the combination of Systematic Literature Review (SLR) and Systematic Mapping Studies (SMS). SLR is "a thorough, methodical, and orderly approach for appraising articles for inclusion" (Sadiq et al., 2019, p. 2). In SLR, relevant studies are searched, evaluated, and synthesized using pre-determined explicit methods (Parris & Peachey, 2013). Likewise, SMS generally aims to map literature and address a broader research question, and involves mapping literature concerning time, location, source, and origin (Peters et al., 2015).

4.2.1 Selection criteria

The selection of articles for the review of CBLRR measures involved the development and application of inclusion and exclusion criteria. The articles were included if they: 1) were written in English or Nepali; 2) had key search terms (as described in Section 4.2.2) in the title, abstracts, or keywords; 3) were about CBLRR measures; and 4) were peer-reviewed articles, conference papers, conference proceedings, book chapters, or dissertations. If the articles described the measures taken by community or household independently without external support, they were assessed for their relevance to self-driven measures of LRR.

Similarly, the selection criteria for articles on self-driven measures were also established. The articles were included if they: 1) were written in English or Nepali; 2) had key search terms (as described in Section 4.2.2) in title, abstracts or keywords; 3) were about household and/or community measures adopted by the households and communities on their own without being driven or supported by 'outsiders'; and 4) were peer-reviewed articles, conference papers, conference proceedings, book chapters, or dissertation. In case the articles described the cases supported by the 'outsiders', they were checked for their relevance in the review of CBLRR measures.

The title, abstract, and keywords of the articles derived by using the search criteria discussed in Section 4.2.2 were compared against the inclusion and exclusion criteria. Where uncertainty arose regarding the compliance with the criteria, the full texts of the articles were studied to inform decisions regarding their inclusion or exclusion for further review.

4.2.2 Search strategy

Three distinct strategies were adopted to search the studies meeting inclusion criteria. According to first strategy (Strategy 1), articles were sought in two academic databases—Web of Science and Scopus. For this, search keywords used for self-driven approaches to LRR were: ((Community* OR Household) AND (methods OR approaches OR responses) AND landslide* AND ("Risk Reduction" OR management OR mitigation OR preparedness OR response OR recovery OR reconstruction OR resilience)) OR ((Local OR Traditional OR Indigenous) AND knowledge AND landslide* AND ("Risk Reduction" OR management OR mitigation OR preparedness OR response OR recovery OR reconstruction OR resilience)). As of 29th May

2023, the keywords search yielded 738 articles on Web of Science and 1012 on Scopus, which form the data analysed here.

Similarly, the combined search terms used for searching CBLRR papers were: ("Community based" OR "Community led" OR "Community managed" OR "Community centric" OR "Community driven" OR "people centric" OR "bottom up" OR participatory) AND "landslide*" AND ("Risk Reduction" OR Management OR Mitigation OR preparedness OR Response OR Recovery OR Prevention OR Resilience). The keywords search yielded 565 articles on Web of Science and 208 on Scopus by 29th May 2023. The alert function was used in Web of Science database to get alerts on new studies for both self-driven and CBLRR measures. No restriction was imposed on the dates of publication while searching for articles. Both self-driven LRR and CBLRR measures are rapidly evolving fields of research, underscoring the possibility that additional research may have been pursued beyond the specified period.

Under Strategy 2, additional articles and papers focusing on self-driven and CBLRR measures, particularly those from Nepal or in Nepali language, were collected using personal knowledge, networks, and targeted searches of websites of government ministries, departments and offices, I/NGOs and UN agencies. Similarly, Strategy 3 employed the snowballing technique, which involved the exploring the bibliographies or reference lists of reviewed articles. Articles identified through strategies 2 and 3 were also checked against the inclusion criteria to determine their suitability for further review.

In total, 71 articles meeting inclusion criteria for self-driven approaches to LRR and 127 studies meeting the inclusion criteria for CBLRR were reviewed in detail, of which 39 and 58 were chosen for analysis, respectively. Figures 4.1 and 4.2 illustrate the steps followed for searching and selecting the studies. Eight out of 58 studies on CBLRR chosen belonged to the publications of I/NGOs and UN agencies working in Nepal.

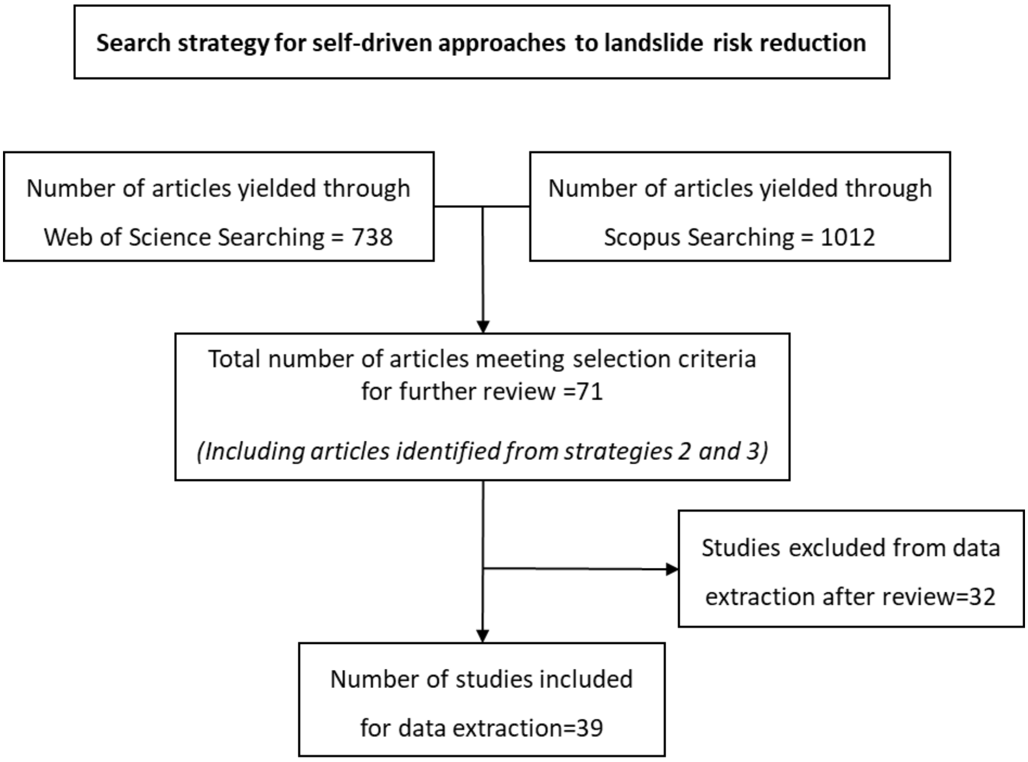

Figure 4.1: Steps for selecting studies on self-driven approaches to landslide risk reduction

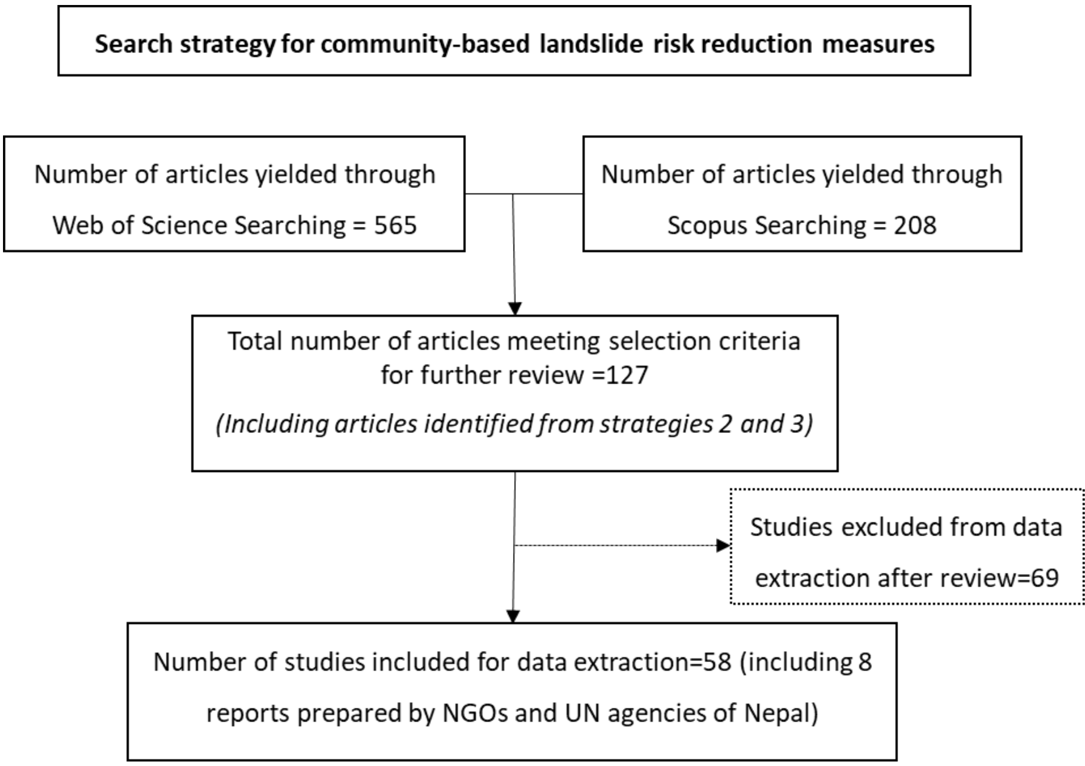

Figure 4.2: Steps for selecting studies on community-based landslide risk reduction measures

4.2.3 Review and data extraction strategy

The studies that met the inclusion criteria were reviewed in detail, and data were extracted for analysis and interpretation. The dimensions of data extracted included, but were not limited to, authors, year of publication, data sources, study area, the title of the study, nature of activities, the scale of implementation, year of implementation, categories of LRR measures, phase of disaster addressed, the role of locals, the role of outsiders, level of participation, successes of the work, challenges/limitations of the work and lessons learned. The summary of the reviewed articles was maintained in database. The list of articles that met the inclusion criteria and were reviewed in detail are provided in the Appendices 5-7.

4.3 Results

The results section details the characterization of self-driven and community-based LRR measures by year, country, source and LRR categories. The CBLRR measures are further categorised by the disaster phase and level of participation.

4.3.1 Self-driven approaches to landslide risk reduction

Thirty-nine studies of self-driven approaches to LRR met the criteria for inclusion in the analysis. Among these, 6 were derived from books, 1 from a conference proceeding, and the remaining 32 were from peer-reviewed articles. The subsequent sub-sections delineate the characterization of selected studies based on the number of studies per year, country, source and LRR categories. The list and further details of the selected studies are available in the Appendix 5.

4.3.1.1 Number of studies on self-driven approaches to landslide risk reduction by year of publication, country, and source

The publication years of the studies used for data extraction were cross-referenced with the timeframe of two key global DRR frameworks: Hyogo Framework for Action (HFA) 2005-2015 and its successor, Sendai Framework for DRR (SFDRR) 2015-2030. Both frameworks underscore the importance of local participation in DRR; however, SFDRR is more explicit about the need to engage with people disproportionately affected by disasters, especially women, children, elderly and youth, persons with disabilities, poor people, migrants and indigenous people (UNDRR, 2005, 2015). Among the reviewed studies, eleven were published before 2005 i.e., before the endorsement of HFA, eight during the HFA timeframe (2005-2014), and twenty were published in or after 2015, coinciding with the ongoing SFDRR timeframe (see Figure 4.3).

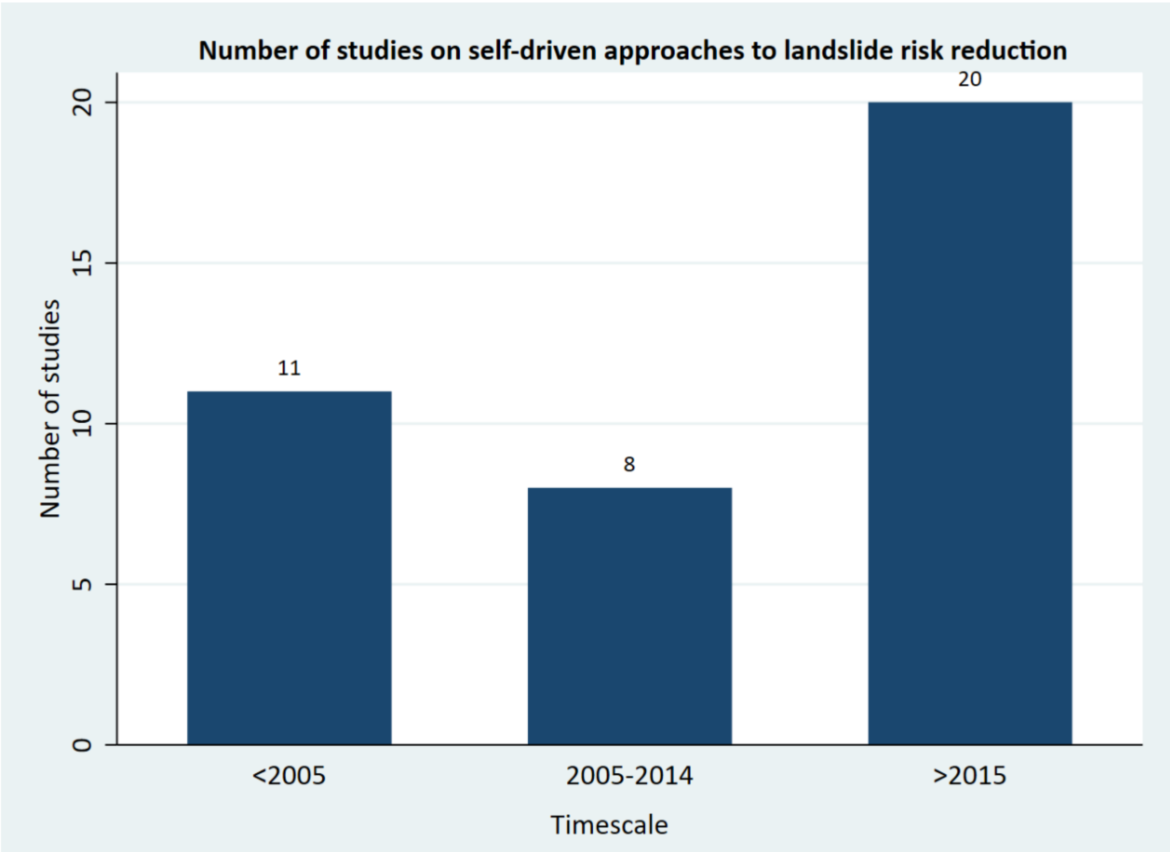

Figure 4.3: Temporal distribution of studies on self-driven approaches to landslide risk reduction

Notably, 75% of the cases originated from countries classified as having low to medium human development status according to 2021's HDI (UNDP, 2022). Likewise, 43% of the cases studied were from Nepal. Approximately 70% of the reviewed studies were led by authors affiliated with institutions based in high and very high HDI countries indicating a predominance of researchers/scholars from developed countries in knowledge production (see Figure 4.4). The journal *Mountain Research and Development* and books/book chapters constituted the primary sources of the selected studies, representing respectively 21% and 18% of the studies.

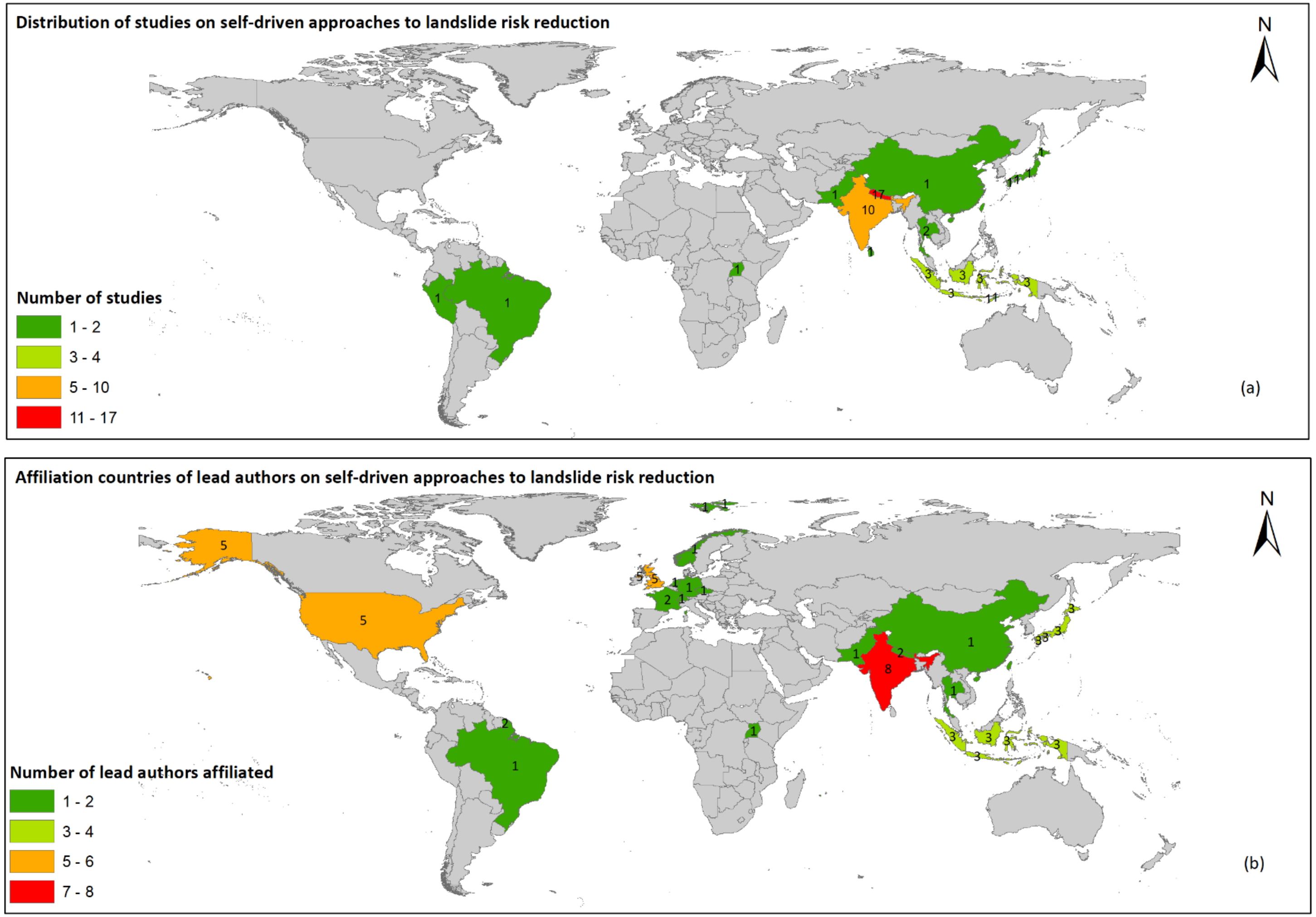

Figure 4.4: World map showing countries with (a) number of studies on self-driven approaches to LRR and (b) affiliation countries of lead authors

(Source of map layer: The World Bank, 2020)

4.3.1.2 Percentage of studies on self-driven approaches to landslide risk reduction per different landslide risk reduction measures

The self-driven approaches to LRR led by households and/or communities without 'external' assistance were categorized using the adjusted classification method suggested by Twigg (2009) and used by Maes et al. (2017). These were classified into seven thematic areas: i) hazard reduction, ii) exposure reduction, iii) vulnerability reduction, iv) response and recovery, v) tacit knowledge, vi) risk assessment and vii) risk acceptance (see Figure 4.5).

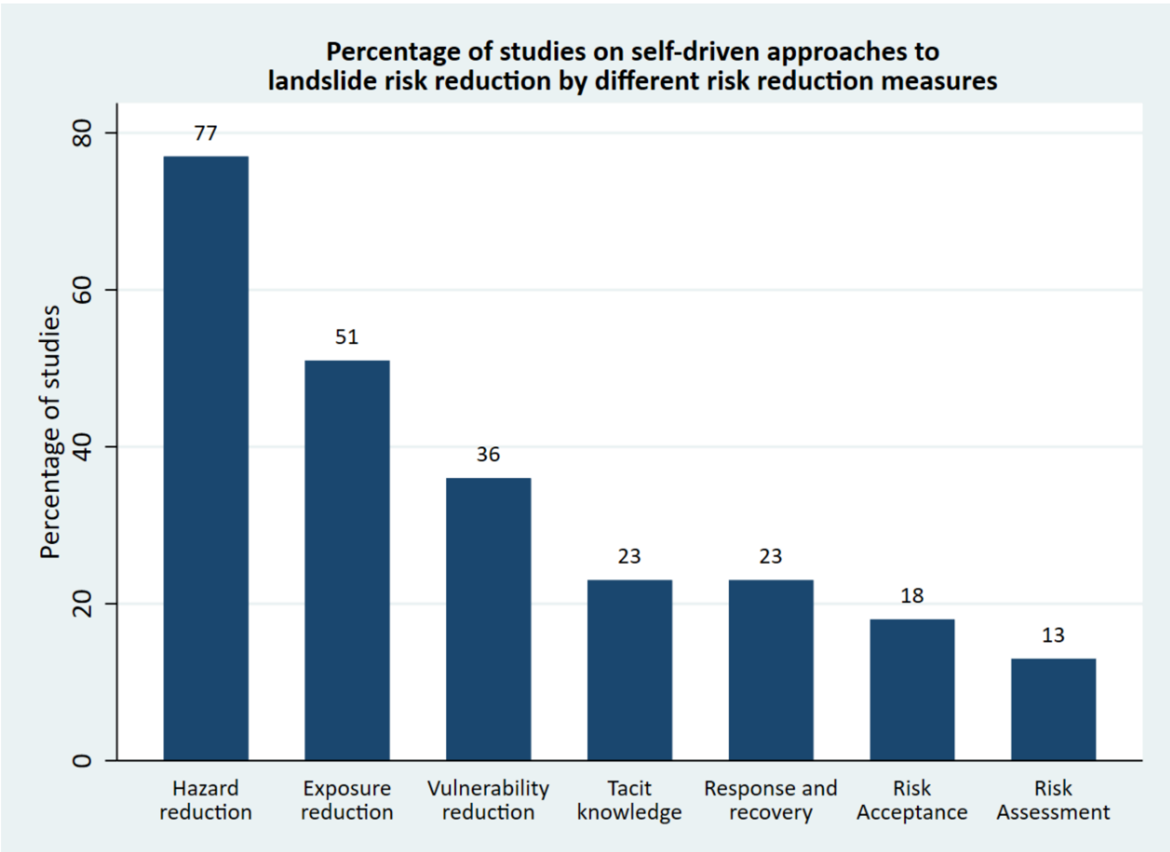

Figure 4.5: Percentage of studies on self-driven approaches to landslide risk reduction by different landslide risk reduction measures

Out of thirty-nine studies, 77% of the studies incorporated hazard reduction approach taken by household/communities such as plantation, drainage management and de-intensifying land use, whereas only 13% of the studies involved risk assessment for LRR. Figure 4.6 illustrates the key self-driven approaches undertaken under different thematic areas as reported in the different studies meeting conditions for review.

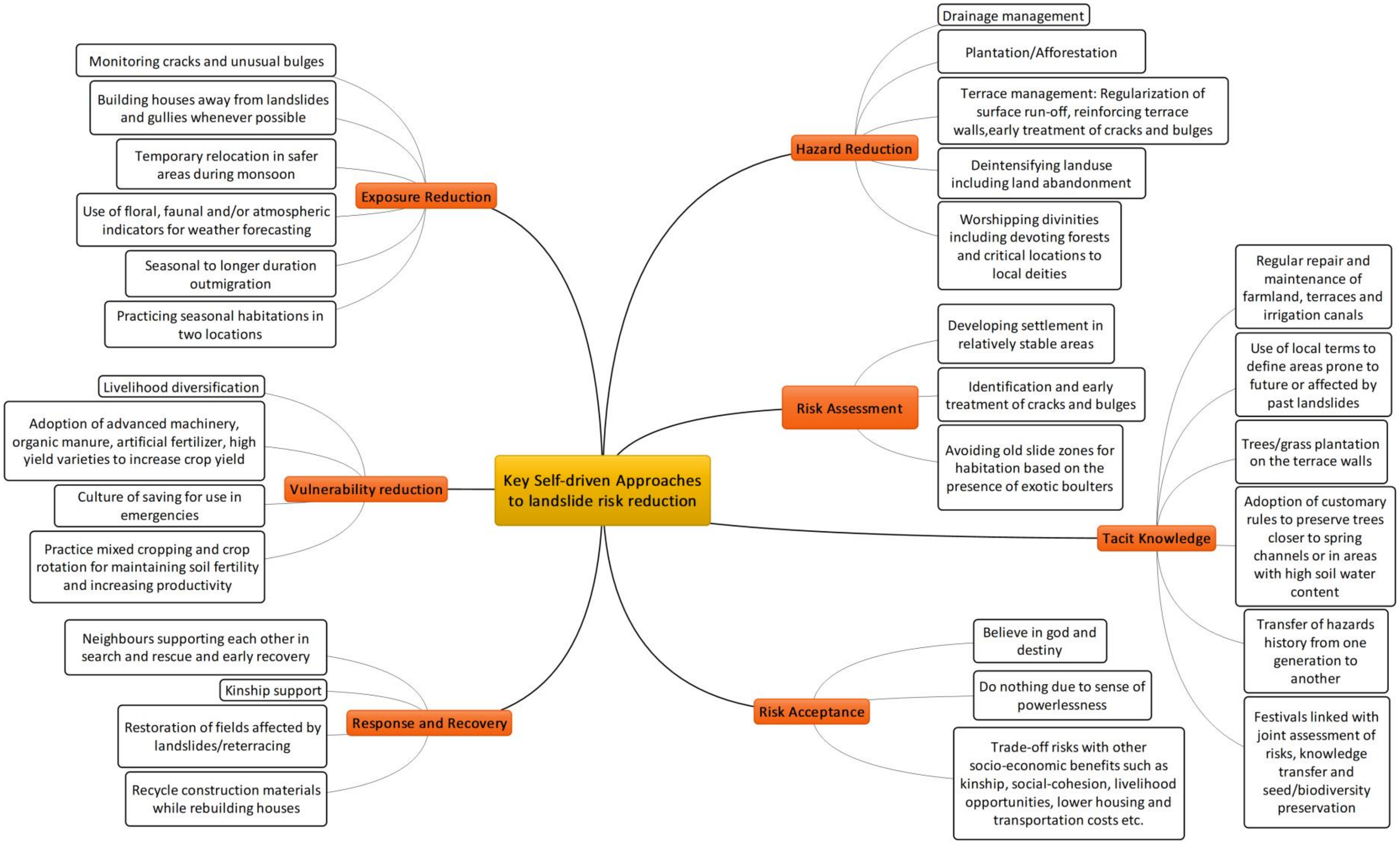

Figure 4.6: Key self-driven approaches to landslide risk reduction identified from systematic literature review

4.3.1.3 Commonalities and differences in self-driven approaches to landslide risk reduction

The review of self-driven approaches to LRR reinforced the widely accepted notion that households and communities are engaged in many activities to reduce risk at both household and community levels as parts of their daily endeavours to support socio-economic wellbeing (Maskrey, 2011). Whilst such activities varied from one household or community to another household or community, certain commonalities were also identified.

Terrace and drainage management, tree plantation, worshipping divinities, de-intensifying land-use and cultivation, seasonal- (and also longer duration) outmigration, avoiding steep slopes for settlement and cultivation, monitoring cracks and ground deformation, and staying temporarily in neighbours' and relatives' houses during rainfall were some of the common approaches cited (see Figure 4.6). Many households prioritized socio-economic benefits such as friendship, social cohesion, income generation opportunities, better healthcare and education, and lower transportation and housing costs over landslide risk by opting to stay in landslide-prone areas (Mendonca & Gullo, 2020; Oven & Rigg, 2015). Communities from Nepal, India, Timor-Leste, and Peru were also found to simultaneously use scientific and religious explanations of disasters and DRR (see, for example, Bjønness, 1986; Klimeš et al., 2015; McWilliam et al., 2020; Pilgrim, 1999).

Distinct risk reduction actions were also observed among the households and communities. For example, some communities of Nepal and India prohibited interventions such as deforestation and cultivation in some landslide-prone areas by dedicating such areas to local divinities (Gergan, 2017; Smadja, 2009). In Uttarakhand (India), farmers avoided the necessity to travel through unstable slopes during the monsoon for paddy plantation by planting early using irrigation facilities (Ritu, 2020). In Sri Lanka's Matale District, locals used the temple bells for disseminating warnings of landslide risks (Dasanayaka & Matsuda, 2019). Likewise, Tamangs from Central Nepal prepared for disasters such as landslides by saving a handful of meals for use during and after disaster events (March, 2002).

4.3.2 Community-based landslide risk reduction measures

Fifty-eight studies of CBLRR measures were included for analysis, comprising 44 peer-reviewed academic articles, 5 conference papers, 1 book chapter and 8 publications from

I/NGOs and UN agencies working in Nepal. Notably, eight of the academic articles centred on the various aspects of the same community-based landslide mitigation project from West Indies, namely *Management of Slopes Stability in Communities* (MoSSaiC). This initiative identified the localized drivers of slope instability and implemented low-cost drainage measures by engaging residents, community development practitioners and local engineers (Holcombe & Anderson, 2010a). During the analysis process, the conference papers and book chapters were treated similar as the academic papers. However, reports and publications from the I/NGO and UN regarding CBLRR measures implemented in Nepal's various parts were analysed separately from peer-reviewed articles and conference papers for easy and clearer interpretation.

The subsequent sub-sections delineate the characterization of selected studies on CBLRR measures based on the number of studies per year, source of publication, country focus, LRR categories, disaster phase addressed, and the level of community participation in such measures. The list of selected studies reviewed in detail is available in the Appendices 6-7.

4.3.2.1 Number of community-based landslide risk reduction studies by year, country, and source

The literature review highlighted that the studies on CBLRR measures is a relatively new but an expanding field. The highest number of articles were published in the year 2017 (8 publications), with the first published in 2006. Figure 4.7 illustrates the temporal distribution of peer-reviewed articles, book chapter and conference papers on CBLRR published in different years. Notably, all the examined grey literature from Nepal were prepared or published after 2008.

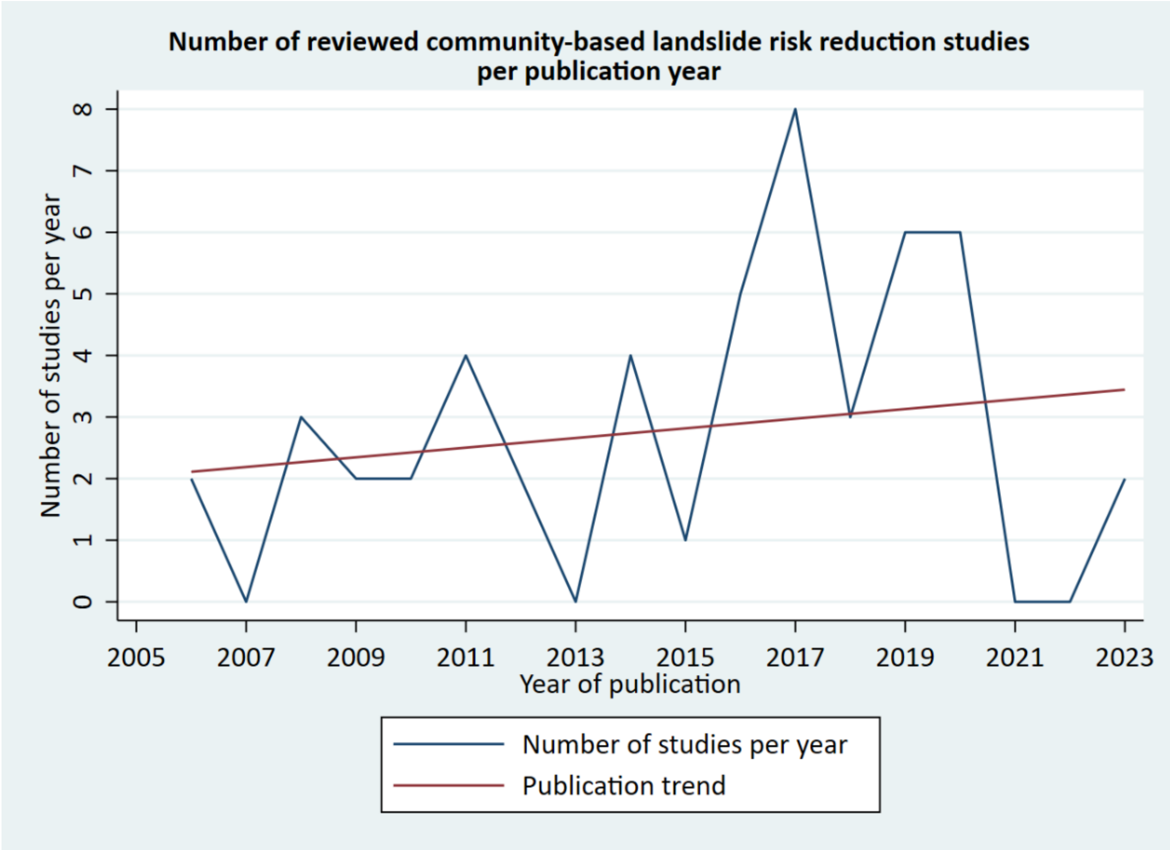

Figure 4.7: Temporal distribution of studies on community-based landslide risk reduction

The highest number of articles were found in journals such as *Natural Hazards* and *Landslides* accounting for respectively 14% and 10% of selected articles published (see Figure 4.8). Of the 50 academic articles (including 5 conference papers), eight were from Saint Lucia whereas five each were from Indonesia and Nepal. Interestingly, all eight cases from the West Indies were about the different aspects of MoSSaiC project implemented in 'informal' settlements on landslide-prone slopes of St. Lucia, West Indies. While Holcombe & Anderson (2010a), Anderson et al. (2008), Anderson & Holcombe (2006) and Holcombe & Anderson (2010b) elucidated the framework of pilot programme on low-cost community-based drainage interventions for LRR named as MoSSaiC, Holcombe et al. (2012) and Anderson et al. (2011) conducted further examinations into the effectiveness of the project. Similarly, Anderson et al. (2014) discussed the emerging challenges of CBLRR projects in developing countries. Holcombe & Anderson (2010a) further underscored the importance of slowing down the project to yield better results, documenting and disseminating evidence of effective practices, and engaging with stakeholders at all levels in scaling up the landslide hazard mitigation measures.

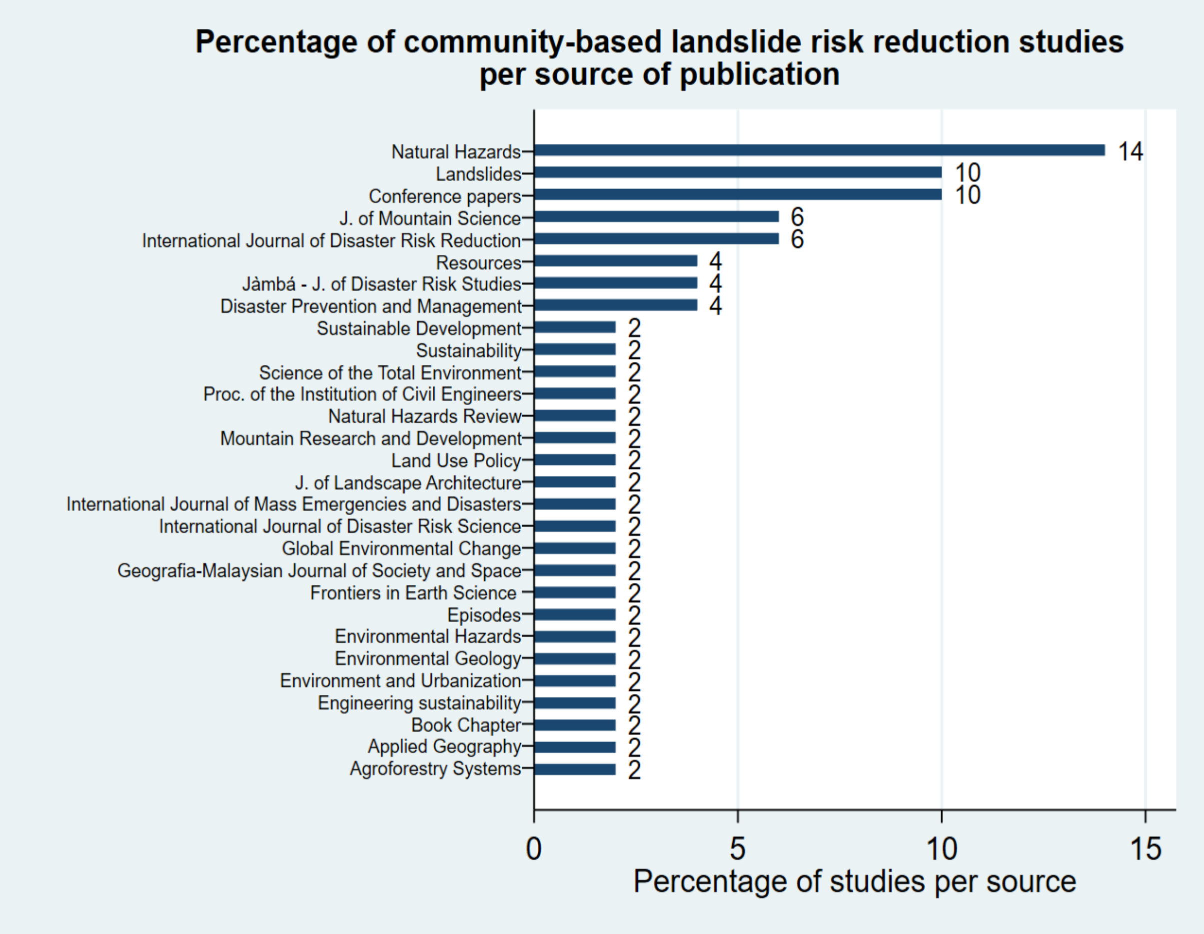

Figure 4.8: Percentage of community-based landslide risk reduction studies per source of publications

Likewise, three out of the five cases from Indonesia were about the establishment of community-based EWS in Karanganyar, Central Java, Indonesia. Despite Asia's substantial share of global fatal landslides (~75%) (Froude & Petley, 2018), the analysis of selected CBLRR studies by country indicated that less than 45% of studies were from this region, with even smaller proportion of lead researchers (only 34%) affiliated with organizations based in Asia (see Figures 4.9 and 4.10). India and Nepal, cumulatively accounting for 26% of global rainfall triggered fatal landslide events (Froude & Petley, 2018), had a lower proportion of publications on CBLRR measures. Specifically, only eight out of the 50 peer-reviewed articles (16%) represented the cases from these countries.

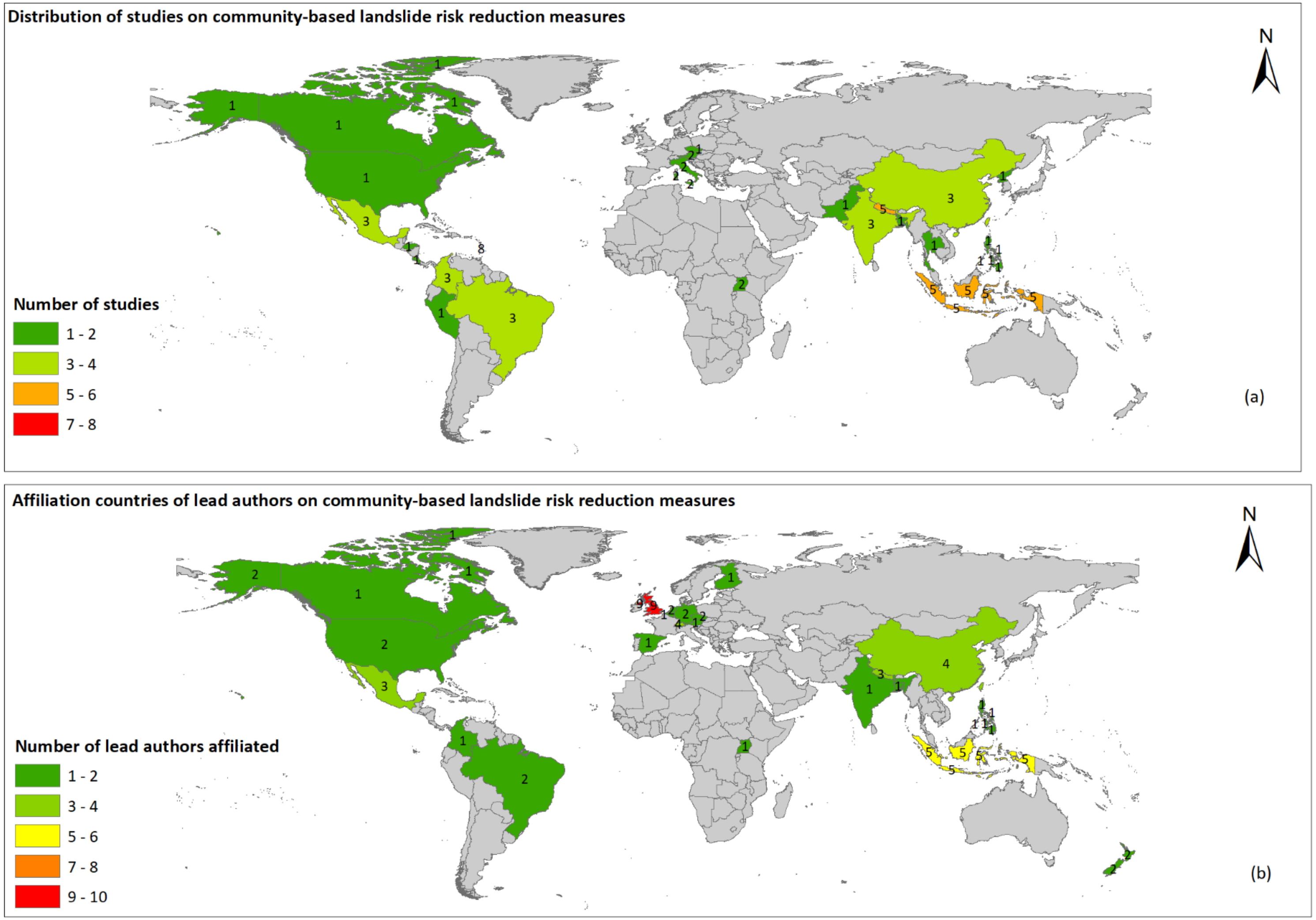

Figure 4.9: World map showing countries with (a) number of studies on CBLRR measures and (b) affiliation countries of lead authors

(Source of map layer: The World Bank, 2020)

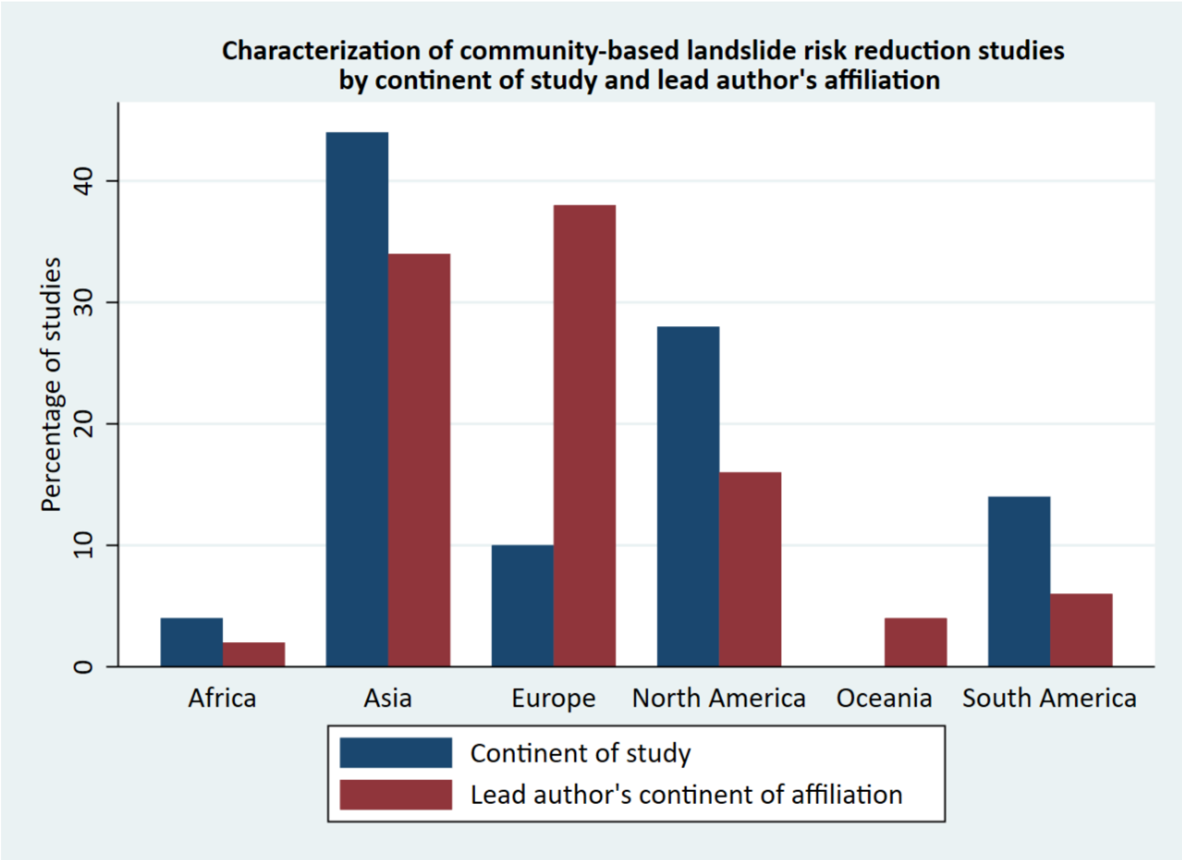

Figure 4.10: Characterization of community-based landslide risk reduction studies by continent of study and lead author's affiliation

4.3.2.2 Number of community-based landslide risk reduction studies per different landslide risk reduction approaches, disaster phase and level of participation

More than 85% of the reviewed studies encompassed measures taken during the pre-disaster phase of landslides, potentially indicating a growing emphasis being given to pre-disaster measures (see Figure 4.11). Sixty-four percent of the reviewed studies included interventions related to risk assessment, whereas 48% included measures related to hazard reduction (see Figure 4.12). Figure 4.12 illustrates the disparity between self-driven and community-based approaches to landslide risk reduction. Households and communities typically focus on hazard and exposure reduction through activities such as terrace and drainage management, deintensification of cropping and land use, temporary relocation to safer areas, and monitoring and early treatment of cracks and unusual bulges in their land. In contrast, external agencies and 'certified' scientists often emphasize conducting community hazard, vulnerability and capacity assessments, forming community disaster management committees, establishing landslide monitoring and early warning systems, preparing preparedness and mitigation plans, and promoting afforestation and bioengineering measures in the communities. This difference reveals the varied priorities between self-driven and externally guided community-based risk reduction strategies.

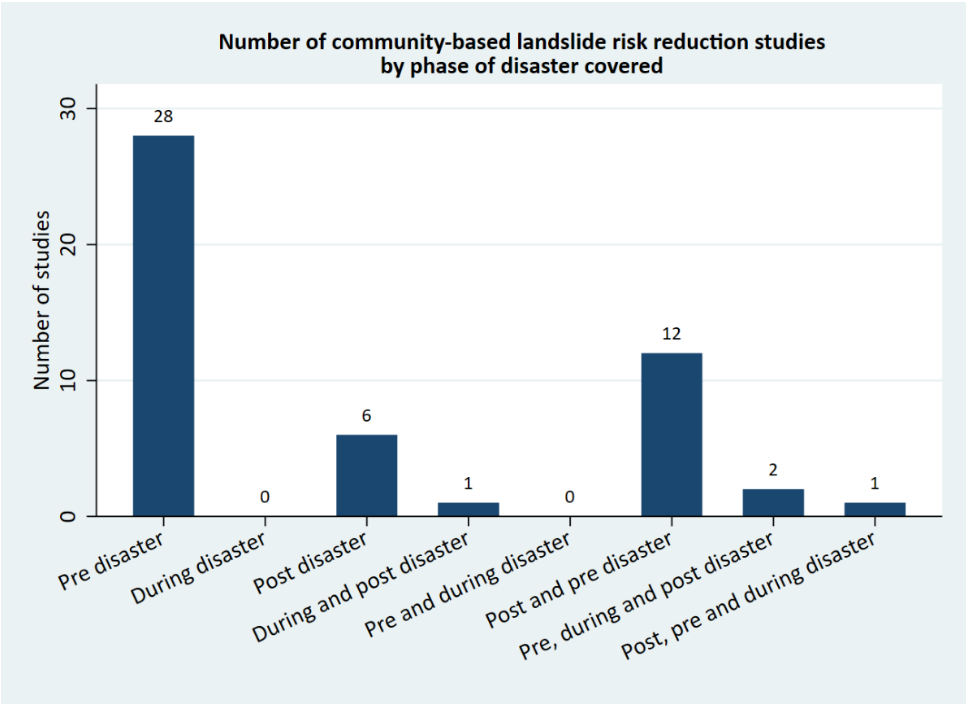

Figure 4.11: Number of community-based landslide risk reduction studies by disaster phase addressed

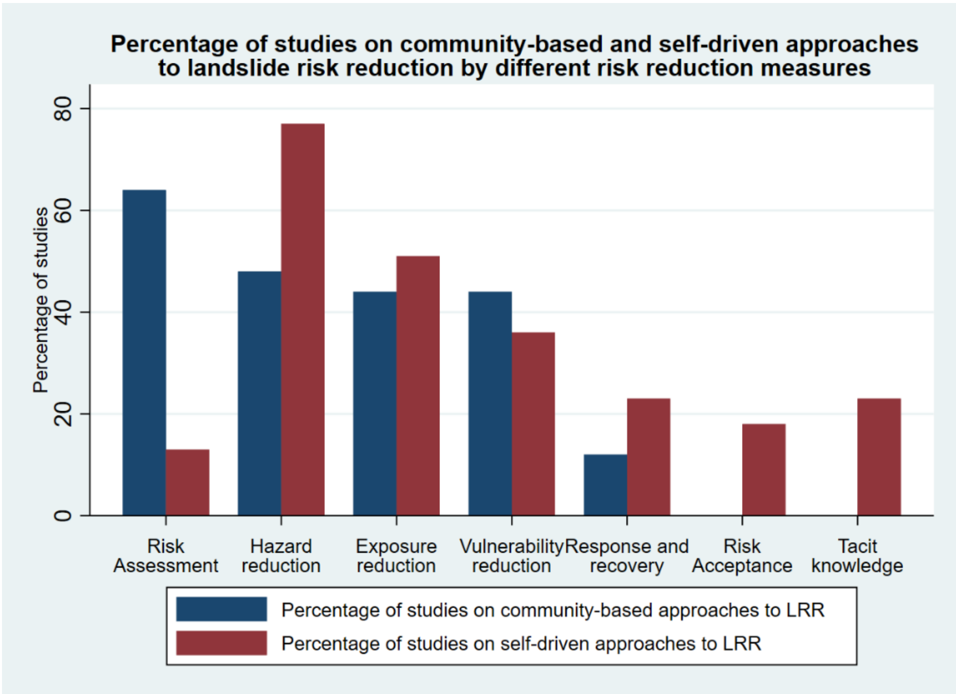

Figure 4.12: Percentage of community-based landslide risk reduction studies by different landslide risk reduction approaches

Regarding the level of community participation, 68% of the cases reviewed fell under the categories of 'consulting' and 'enticing' according to categorization by Dyball et al. (2007), where the supporting external agencies hold the decision-making power and the role of participants is to provide information or to act as suggested by those agencies (see Figure 4.13). Only two articles, Petterson, Nanayakkara, et al. (2020) and Petterson, Wangchuk, et al. (2020), both focusing on the role played by students and teachers of Students' Educational and Cultural Movement of Ladakh (SECMOL) in India, fell under the co-acting mode of participation. However, even in these cases, while the participation of students and teachers involved could be categorized as being co-acting, the participation of the wider public fell under the category of consultation. Likewise, Figure 4.14 summarizes the common CBLRR approaches found documented in the studies reviewed in this systematic literature review.

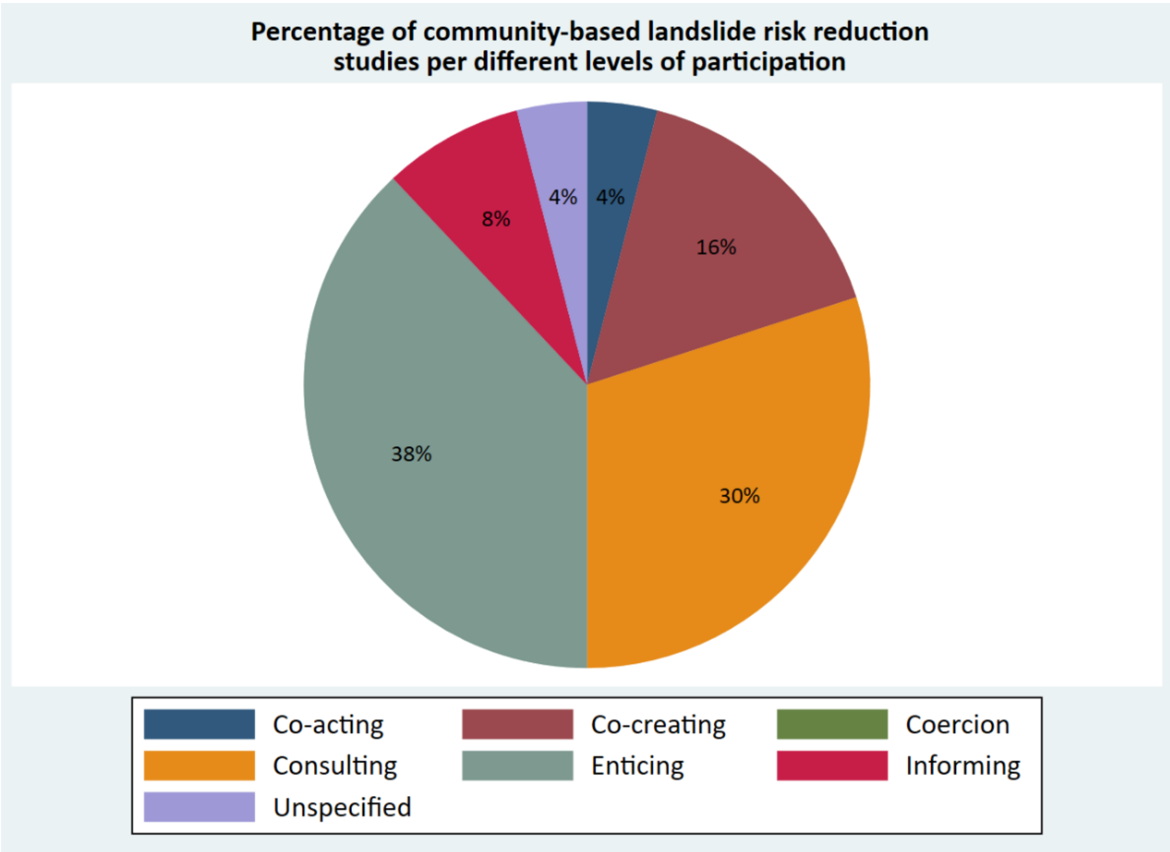

Figure 4.13: Number of community-based landslide risk reduction studies by levels of participation

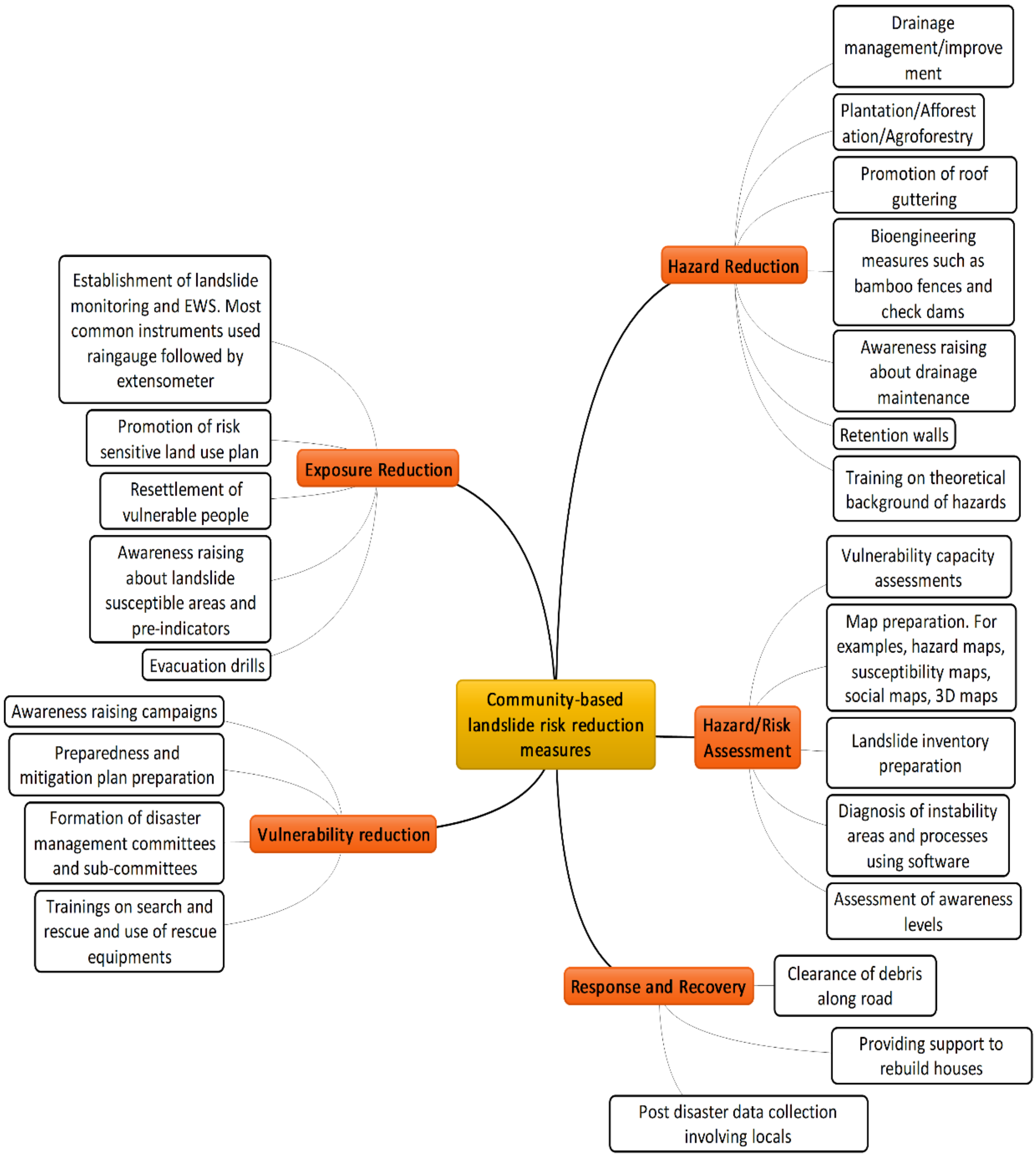

Figure 4.14: Common CBLRR measures identified from systematic literature review

4.4 Discussions

With only 58 studies meeting the review criteria for CBLRR measures, the relatively low number of studies about CBLRR measures could reflect the overall lesser number of CBLRR projects due to overall complexity in understanding, predicting, mitigating and managing the landslides (Guzzetti et al., 2020; Oven et al., 2021).

Only 28% of the peer-reviewed articles (including conference papers) on CBLRR measures were from the countries with low to medium HDI according to 2021's HDI (UNDP, 2022). On one hand, this could suggest that the lower-income countries have relatively lesser numbers of CBLRR efforts compared to the middle- or higher-income countries, highlighting the need to bolster such efforts in such countries. However, on the other, this could also be due to the lesser emphasis given in publishing such initiatives in academic literature. Using personal networks with NGO professionals in Nepal and searching through the organizations' websites, I uncovered eight grey literature reports on CBLRR measures, indicating the likelihood of numerous CBLRR measures being primarily limited to donor reporting and internal documentation only, rather than being published in peer-reviewed journals.

While the early publications on self-driven approaches to LRR date back to the 1980s, the early publications on CBLRR measures stemmed from the mid-2000s, indicating the CBLRR is relatively newer field of inquiry. The review also indicated the overall upward trends in the number of publications on CBLRR measures over time, suggesting that the sector is growing with time. The subsequent sections will highlight the successes and obstacles associated with implementing CBLRR measures.

4.4.1 Some of the challenges and limitations of community-based landslide risk reduction measures

As highlighted above, the participation level of communities in most of the CBLRR projects primarily fell under 'consulting' and 'enticing' according to Dyball et al. (2007)'s categorization. The findings align with the criticisms of general community-based programmes, that often use participation as a management tool to reduce opposition to externally-driven plans, rather than addressing the underlying root causes and structural issues comprehensively (Cooke & Kothari, 2001). Such form of participation may do little to benefit ethnically marginalized groups, financially poor, women, elderly, and persons with disabilities as highlighted in the contexts of community forestry in Nepal (Nightingale, 2005, 2017), and can be compared with what Cooke & Kothari (2001) referred to as 'participation as presence and performance' rather than as the 'power'. Supporting agencies, including government institutions and non-government organizations, and researchers should place greater emphasis on understanding and integrating local power dynamics into their strategies to not only prevent 'elite capture'

(Nadiruzzaman & Wrathall, 2015; Nightingale, 2005), but also to meaningfully empower the marginalized groups in CBLRR projects and research (Cooke & Kothari, 2001; Maskrey, 2011).

This review also highlighted that the authors affiliated in institutions or organizations from high to very high HDI countries exerted significant influence over the studies on self-driven and CBLRR measures with only 21% of the studies being led by authors affiliated in countries with low to medium HDI. Such situation may cause imposition or imitation of ideas or information of researchers from developed countries, potentially resulting in research, policies and practices that do not reflect the contexts and needs of developing countries (Andrabi, 2022; Cadag, 2022). Hence, to counteract the knowledge hegemony, more and more researchers from low- to medium- income countries should come forward for ensuring more inclusive and sustainable knowledge production, and minimize 'outside' biases (Cadag, 2022; Gaillard, 2022a). It is crucial that the government entities and international funding agencies allocate more resources to create an enabling environment for researchers and research institutions from low-to-medium income countries to engage in research on self-driven and community-based LRR measures (Andrabi, 2022).

This review also stressed that despite the success of CBLRR measures during the project period, a significant challenge lies in sustaining and scaling-up these measures beyond the project lifespan. Multiple articles highlighted the challenges in providing refresher training to the community level committees, as well as maintaining and repairing landslide monitoring devices and mitigation measures post-project (see, for example, Hostettler et al., 2019; Malakar, 2014). Therefore, long-term exit strategies empowering communities to take actions to hold governments accountable (Gladfelter, 2018) and to continue LRR measures with minimum external support are essential (Klimeš et al., 2019).

This review also identified a disparity between the community and household priorities, and the approaches promoted in CBLRR initiatives. In many CBLRR projects, supporting agencies treated the needs, vulnerabilities, and capacities of different groups and sub-groups within a community as being homogenous and static (Anderson et al., 2014). The diversities of communities and places, socio-economic dimensions, and peoples' networks and actions were often overlooked (Maldonado, 2016; Mosse, 1995). CBLRR efforts largely neglected the socio-cultural processes generating differential vulnerabilities and local ways of addressing the risks (Krüger et al., 2015; Oven et al., 2021). Self-driven measures such as de-intensifying land-use, social support mechanisms, indigenous knowledge of monitoring cracks and bulges, and trading-off landslide risks with socio-economic benefits were not adequately incorporated in CBLRR measures. Such disregard might obscure the perceptions, interests, and opinions of the sub-dominant groups within the communities (Mosse, 1995; Oven et al., 2021) and might not give sustainable results. Hence, researchers and supporting agencies should abstain from promoting socio-politically 'neutralized' or standardized measures and give due consideration to local culture and power asymmetries in CBLRR studies and interventions (Cannon, 2015; Gaillard, 2022a; Huber et al., 2017).

Many studies on self-driven community and household approaches highlighted the existence of a pluralistic approach of using both religious and non-religious actions to reduce landslide risks (see, for example, Klimeš et al., 2019; Pilgrim, 1999), but the community-based projects hardly incorporated the religious or spiritual aspects in their programs (Oven et al., 2021). Failures to accommodate religious and cultural aspects might raise deeper cultural anxieties, and conflicts between the proponents of different discourses (Gergan, 2017; Ripert, 2009; Scolobig et al., 2016). Moreover, community-based projects mainly focused on risk assessment (64% of studies), hazard reduction (48%) and exposure reduction (44%) rather than addressing the underlying causes of vulnerabilities. Although 44% of the CBLRR studies mentioned about the vulnerability reduction efforts, most of them centred on superficial measures such as formation the disaster management committees, supporting them to prepare disaster preparedness and mitigation plans, and running awareness raising campaigns rather than addressing deeper root causes such as structural discrimination and inequalities in access to resources and decision-making. Promoting normative and standardized lists of CBLRR strategies that often fail to align with the priorities of marginalized groups (Gaillard, 2022a; IFRC, 2014) are akin to what Tania Murray Li (2007, 2016) refers to as *'Rendering Technical'* in the contexts of Indonesia's development projects. Such approaches are usually ineffective in achieving longer-term outcomes in landslide risk reduction.

Another significant obstacle to the effectiveness of CBLRR measures lied in aligning the spatial resolution of hazard assessment with the scale of instability (Hostettler et al., 2019). Hazard assessment and mapping emerged as one of the most frequently implemented interventions in community-based projects (Klimeš et al., 2019). Based on the literature review, the development of effective risk reduction measures may necessitate higher resolution mapping and some parameters to be considered at household levels (Holcombe & Anderson, 2010a). Furthermore, such maps must be regularly updated to remain relevant (Jaiswal & van Westen, 2013; Oven et al., 2021). While coarse resolution maps offer valuable insights for strategic planning for local governance structures (Cieslik et al., 2019), overreliance on them could exacerbate risk accumulation given the variability in preparatory and triggering processes for individual landslides (Anderson et al., 2014). Similarly, technical maps may be difficult for local community members and local government authorities to fully comprehend (Karnawati, Fathani, Wilopo, et al., 2011; Maes et al., 2017). Using aerial photographs, three-dimensional maps, and participatory three-dimensional models might be more effective compared to using contour maps while communicating the hazard and risk information to the stakeholders and at-risk populations (Basyal, 2021; Haynes et al., 2007).

This review also highlighted that many landslide studies treat the future landslide frequency as being the same as the recent trends (Chen & Wu, 2016). A recent study by KC et al. (2024) illustrates the spatial-temporal variability of landslide trends in the Nepal Himalayas. Despite the dynamic nature of landslide hazards and risks (Rosser et al., 2021), almost all the reviewed projects did not mention anything about what has been done to capture such physical dynamism. It is crucial for the CBLRR plans to account for rapidly changing demographic characters and other anthropogenic factors influencing landslide risks, necessitating regular review and update (Liu et al., 2016; Rigg & Oven, 2015). Furthermore, this review reinforces the idea that residents and stakeholders of communities are socio-economically and culturally diverse. Consequently, challenges may arise in building consensus regarding potential solutions and responsibility-sharing for the implementation of CBLRR measures (Hostettler et al., 2019; Oven et al., 2021; Scolobig et al., 2017).

4.4.2 Some of the successful community-based landslide risk reduction measures

Besides the challenges discussed above, this review also brought to light the successful CBLRR measures in reducing landslide risks. A consistent finding of the review was the positive role played by community-level committees in hazard assessment, awareness-raising, identifying and implementing LRR measures, and acting as the intermediary between communities and practitioners/scientists/public authorities (see, for example, Anderson & Holcombe, 2006;

Hostettler et al., 2019; Karnawati et al., 2009; Malakar, 2014; Tappenden, 2014). The community-level committees also demonstrated their potential in data collection about hazards and filling the data gaps (see, for example, Jacobs et al., 2019). The catalytic role of community leaders in communicating the project's objectives to residents and facilitating collaboration between communities and external agencies was also highlighted as a key success factor of CBLRR measures (see, for example, Anderson et al., 2014; Klimeš et al., 2019). However, engaging with community leaders and community-level committees in CBLRR should be done with caution as relying excessively on community leaders or certain groups only may enhance 'participatory exclusions' and prevent vulnerable groups from participating in decision-making processes (Agarwal, 2001; Dyball et al., 2007; Nagoda & Nightingale, 2017).

Furthermore, the review emphasized the potential of using maps for various purposes, including awareness-raising (Ruiz-Cortés & Alcántara-Ayala, 2020) and negotiating with local government for mitigation investments (Klimeš et al., 2015). The review also included the articles that documented the positive impact of CBEWS in reducing the loss of life and injuries (see, for example, Karnawati et al., 2009; Liu et al., 2016; Malakar, 2014; Marchezini et al., 2017; Schmidt-Thomé et al., 2018; Thapa & Adhikari, 2019), although at times direct attribution of the benefits can be problematic. Review highlighted uncertainties in susceptibility zonation, rapid changes in landslide hazards, false alarms, communication difficulties, and the complex nature, types, and preparatory and triggering factors of landslides as the key challenges of landslide EWS (Guzzetti et al., 2020; Oven et al., 2021; Thapa & Adhikari, 2019). Rainfall emerged as the most commonly monitored parameter in community-based landslide EWS whereas there were some attempts to monitor the slope displacement using manual wooden posts (Mercy Corps Nepal, 2016); auto-extensometers (Karnawati et al., 2009; Thapa & Adhikari, 2019); and piles, mosaic, smartphones and convergence meters (Liu et al., 2016).

Another overarching theme underscored through this review is the importance of employing multiple strategies instead of relying solely on a single approach to LRR, such that even though one approach fails, others lead to positive outcomes. Examples of using multiple approaches include the use of both manual and automatic equipment to monitor landslides (Malakar, 2014); monitoring of both stress and strain factors using rain gauges and extensometers in tandem (Karnawati, Fathani, Ignatius, et al., 2011; Liu et al., 2016; Thapa & Adhikari, 2019);

using multiple thresholds to reduce the chances of missed alarms (Lempert et al., 2023) although this could be complex and might only reduce, but not fully eliminate, the false and missed alarms (Piciullo et al., 2018; Thapa et al., 2023); multiple ways of engaging in outreach and awareness-raising (Alcántara-Ayala & Moreno, 2016; Petterson, Nanayakkara, et al., 2020). The involvement of students and youths was found to bring positive outcomes (Marchezini et al., 2017; Murthy et al., 2014; Petterson, Nanayakkara, et al., 2020; Ruiz-Cortés & Alcántara-Ayala, 2020). Similarly, Klimeš et al. (2019) highlighted the utility of community event calendar that documents both past and future community events in understanding the community dynamics and fostering trust-building process. Such calendars could also be useful in planning outreach and capacity-building initiatives.

Additionally, this review featured the effectiveness of reforestation (Nakileza et al., 2017); ecosystem-based approaches such as soil bioengineering techniques (Hostettler et al., 2019), afforestation, ecosystem conservation and management and agroforestry (Xu et al., 2012); low-cost drainage designs (Anderson & Holcombe, 2006); and clearing debris from water channels (Coles & Quintero-Angel, 2018) in mitigating landslide risk. Strategies such as peer-to-peer education, where one generation learns from another (Marchezini et al., 2017), and use of the internet for knowledge sharing (ibid), and exchange visits between communities with and without landslide experiences (Hostettler et al., 2019) were emphasized as effective methods for co-learning and awareness-raising.

This review also identified multiple studies that highlighted the potential of using technology in CBLRR. While Scolobig et al. (2016) described the potential of using internet-based platforms such as Facebook groups and email in engaging wider audiences, Jacobs et al. (2019) and Murthy et al. (2014) amongst others highlighted the potential of using Android-based applications in rapid collection of hazards data.

Additionally, many studies highlighted that the existence of diverse perspectives, interests and worldviews within a community could lead to contestation during the planning and implementation of risk reduction measures (see, for example, Preuner et al., 2017; Scolobig et al., 2016; Scolobig & Lilliestam, 2016). Therefore, proper community engagement strategies should be carefully implemented to identify and accommodate such diversity. Approaches like participatory 3D-mapping (Kusratmoko et al., 2017) and the interactive mock-up models

(Mendonca & Valois, 2017) were highlighted as effective means of engaging communities and stakeholders in constructive dialogue about landslide issues and their potential solutions.

4.5 Conclusions, recommendations, and policy implications

This chapter conducted a comprehensive review of 39 self-driven approaches to LRR and 58 CBLRR studies. According to Dyball et al. (2007)'s categorization, the participation levels in most of the CBLRR projects were limited to 'consultation' and 'enticing' underscoring the need to improve efforts and strategies to enhance the participation levels. Moreover, the review also highlighted that there is a concentration of studies on self-driven and CBLRR measures in countries with high and very high HDI (>49% of studies) and led by authors affiliated with organizations in high and very high HDI countries (~ 78% of studies). This highlights the need to promote more research and initiatives in low- to medium- HDI countries from Asia and elsewhere through local institutions to enrich and balance knowledge production (Gaillard, 2022a). This study also highlighted that most CBLRR projects focused on risk assessment, landslide hazard reduction and monitoring efforts. While not refusing the effectiveness of such efforts, it is essential to underscore the importance of strengthening measures aimed at addressing the deeper root causes of vulnerability to achieve sustainable outcomes (Wisner et al., 2004). Although, risk assessment and hazard zonation were amongst the most common CBLRR measure, there was hardly any project that mentioned about the measures to assess the dynamic nature of risks. The future CBLRR projects should prioritize strategies to capture spatial and temporal changes in landslide risks.

This study is not free from limitations. Despite employing a systematic approach in searching and reviewing the literature, some relevant studies on self-driven and community-based approaches to LRR may have been overlooked. Additionally, this review may also have missed some innovative or noteworthy LRR measures that did not align with the study's search strategy. Despite these limitations, the review findings are believed to make some important contributions in the sector of CBLRR. Based on this study, seven key recommendations and policy implications have been formulated whose level of applicability will largely depend on the nature of landslide vulnerabilities and risks, community context, and available resources in respective communities:

i) CBLRR measures should strengthen collaboration with communities

Despite emphasis given to the necessity for strengthening collaboration with people, public and private sectors, civil society organizations, academia and research institutions for achieving sustainable outcomes within the global DRR frameworks on DRR such as HFA and SFDRR (UNDRR, 2005, 2015), this review revealed the overall less than satisfactory status of collaboration. Hierarchical top-down approaches dominated the CBLRR efforts. Only 20% of the CBLRR measures documented in peer-reviewed articles (including conference papers and book chapter) had participation levels that fell under the category of either 'co-creation' or 'co-acting'. Likewise, 100% of CBLRR measures documented in grey literature from Nepal had participation limited to 'enticing', searching occasional information from different groups through community meetings, interviews and focus group discussions or incentivizing communities by providing grants for implementing the LRR measures. The supporting organizations were primarily responsible for decision making on CBLRR measures. Intentionally or unintentionally, such lower levels of participation may merely be used as a means to increase central control and validity of the plans promoted by donors, rather than empowering the vulnerable people (Cooke & Kothari, 2001; Nagoda & Nightingale, 2017). Marginalized people may find engagement in such project activities as a waste of time if they lack influence over decision-making (Nagoda & Nightingale, 2017). Respecting local culture and opinions (IFRC, 2014), understanding local power dynamics (Kelman et al., 2012), and maintaining clear and regular communication with project participants (Holcombe & Anderson, 2010a; Zimmermann & Issa, 2009) were identified as useful factors in fostering greater trust, legitimacy, ownership, and participation in CBLRR efforts. Furthermore, another key takeaway from the review is the necessity for a radical shift in the way of working with communities to improve the levels of participation and to transform the community-based projects into community-led.

ii) CBLRR should give more attention to understand the cultural dimensions

Understanding and incorporating cultural factors is significant in dealing with natural hazards (Krüger et al., 2015). Place attachment, reciprocity from neighbours and community, gender roles, traditional access to and control of resources, livelihoods, moral values, rituals and religious beliefs, indigenous knowledge and knowledge transfer mechanisms etc. were some of the important cultural dimensions influencing landslide risk and community-led approaches to LRR. However, the cultural values and intra-community dynamics were commonly neglected or insufficiently considered in most of the CBLRR measures reviewed. IFRC (2014) highlighted that people's willingness to engage in and support DRR programs decreases when the cultural aspects are disregarded. Similarly, Oven et al. (2021), in the context of post-2015 earthquake reconstruction in Nepal, highlighted that the cultural aspects such as the place's religious and symbolic values influence people's decisions regarding relocation from geo-hazard prone areas. In short, this review stresses out the necessity to give more efforts in understanding and incorporating the cultural dimensions to get sustainable results in CBLRR measures (Cannon, 2015).

iii) CBLRR should give more attention to understand the socio-economic dimensions

While the influence of socio-economic inequalities and power relations on disaster risk and coping capacity have widely been accepted, particularly after the emergence of the concepts of 'vulnerability paradigm' and 'political ecology' in the 1970s (Aboagye, 2012; Oliver-Smith, 2016; Wisner et al., 2004), this review shows that the CBLRR programs predominantly focus on assessing risks and addressing the physical aspects of landslide hazard (Mendonca & Gullo, 2020), often overlooking the socio-economic (and cultural contexts) in which the risks are rooted. Community-based Disaster Risk Reduction (CBDRR) projects that do not address the root causes of vulnerability do not necessarily empower local people (Gladfelter, 2018). More than 55% of the reviewed CBLRR projects did not include any measures to address socio-economic vulnerabilities. Even those that had, often offered only superficial interventions such as committee formation, plan preparation and running awareness raising campaigns, mirroring the Eurocentric normative and standardised approach to DRR (Gaillard, 2022a). This review suggested the necessity to give more effort in understanding and addressing the underlying root causes such as internal power inequalities, limited access to resources and decision-making processes, and historical patterns of marginalization to achieve sustainable results in CBLRR, rather than simply focusing on the technical aspects (Sudmeier-Rieux et al., 2012).

iv) More attention is needed on small-scale landslides

While many studies have highlighted that the cumulative impacts of small-to-medium scale landslides in peoples' lives and livelihoods is comparable with that of large-scale landslides (Bowman, 2022; Cadag et al., 2017; Froude & Petley, 2018), this review reinforced the notion that smaller-scale events are generally neglected in CBLRR efforts (Sudmeier-Rieux et al., 2013). The aid donors, researchers, and other agencies focused mostly on eye-catching, extreme, and large-scale landslide events. Usually not reported, small-scale landslides (< 1m deep) are quite common and can cause detrimental impacts on rural lives and livelihoods upon prolonged exposure (Ritu, 2020; Sudmeier-Rieux et al., 2012). Therefore, priority should be given in understanding and reducing the risks of small-to-medium scale landslides before they turn into bigger events (Thapa et al., 2023). The identification and mitigation of risks of small-to-medium scale disasters can enhance capacity in managing risks from larger ones as well (Bull-Kamanga et al., 2003; Holcombe & Anderson, 2010b).

v) CBLRR measures should concurrently address everyday risks and landslide risks

Studies reviewed for this chapter highlighted that communities and households quite often trade-off landslide risks with livelihood and human development opportunities by staying in or shifting to landslide-prone areas (Oven & Rigg, 2015; Pilgrim, 1999). What may seem like an irrational behaviour to outsiders might be related to people's rational comparisons of risks (Wachinger et al., 2013). People are typically concerned with immediate and everyday problems like food, children's school fees, water, and minimising road accidents (IFRC, 2014). Comparing the interventions promoted by DRR institutions with 'scratching where people don't have itch', IFRC (ibid) stressed the need to balance the potentially extreme but less frequent hazards with everyday issues in CBDRR programs. Hence, where possible, initiatives addressing both landslide risks and day to day risks—such as road improvements addressing both mobility, drainage, and slope stability issues, waste management addressing both public health issues and problems caused by the accumulation of unstable materials on slopes—should be implemented simultaneously (IFRC, 2012; Mendonca & Gullo, 2020).

Out-migration was one of the most common coping mechanisms among households prone to and affected by landslides. While in short-term, out-migration helps households remain relatively food secure and access better health and education opportunities, it can have longer-term negative consequences on the kinship bonds and social networks (Adger et al., 2013; Cieslik et al., 2019). Out-migration also increases the workload of women, elderly and children, particularly in managing subsistence agriculture (Campbell, 2017, 2018; Sherry et al., 2018), and negatively impacts the physical and mental health of family members (Tachibana et al., 2019). Beside these, the labour scarcity caused by out-migration of youths compels people to neglect the critical tasks of maintaining and repairing irrigation canals and farmland (Cieslik et al., 2019; Nightingale, 2003; Rautela, 2020). In such situations, mechanisms to support farmers to maintain farmland and canals could help reduce soil erosion and landslide risks.

Additionally, studies on community-based measures to LRR highlighted that some families resort to short-term coping strategies, including reducing food intake during each meal (March, 2002), spending savings and reserves (Nizami et al., 2019), and selling high-value staple crops like paddy to buy cheaper grains for household consumption (Blaikie & Coppard, 1998). Such practices can exacerbate vulnerabilities by diminishing their coping capacities to cope with future disaster (IFRC, 2016). Therefore, it could be worthwhile to support households in developing appropriate livelihood strategies (Blaikie & Coppard, 1998), alongside awareness-raising and other risk reduction activities. When planning and implementing development interventions and community-based solutions aimed at increasing resilience, the intersections between such interventions and potentially resulting precarity should be recognized and carefully dealt (Gladfelter, 2018; Rigg et al., 2016; Rigg & Oven, 2015).

In essence, a practical recommendation for policymakers and civil society organizations is that the CBLRR measures should not only aim to reduce the direct loss of life and property but also carefully consider improving people's livelihood and living conditions (Schelchen et al., 2017).

vi) CBLRR approaches should be multi-dimensional and adaptive to address emerging challenges and opportunities

CBLRR initiatives should be adaptive to address rapid urbanization, migration and population aging (Liu et al., 2016). In addition, they have to consider climate change, environmental degradation, changes in poverty levels and regulatory frameworks that might alter the landslide risks and risk reduction strategies within communities (Anderson et al., 2014; Eyler et al., 2022). Oven et al. (2021) underscored the change observed in the characteristics of landslides in Nepal. They highlighted the transitioning in landslide nature from the occurrence of frequent smaller shallow landslides typically linked with road construction or larger slow-moving, deep-seated, disruptive landslides to a greater prevalence of debris flows, particularly after the 2015 Gorkha earthquake. People's movement—both domestic and international, and both temporary and longer-term—for better livelihoods and opportunities, is widespread (Campbell, 2018). There, where the migration of people for socio-economic reasons is common, the risk communication strategies should encompass both local inhabitants and the floating population (Alcántara-Ayala & Moreno, 2016).

At present, most of the CBLRR measures reflect the design and implementation of measures viewing communities as place-based social entities (Gaillard, 2022a; IFRC, 2014). With technological advancements particularly in the information and electronic communication, rapid urbanization, migration, and globalization of goods and services, multiple cross-scale networks are established within communities, and hence, previously localized communities are no more localized (Ojha et al., 2016). Local people have always been in interactions and exchange across scales (Agrawal, 1995; Nightingale, 2015). Hence, as further emphasized by Ojha et al. (2016) in the contexts of natural resource management, community-based projects should move away from 'blueprint' interventions and consider new models of delocalized community in CBDRR measures. Thus, the lessons garnered from this review suggest that CBLRR measures should extend beyond the immediate area at risk and physical hazards, consider multiple stressors and opportunities, and reflect the ways the communities are organized and structured (Oven & Rigg, 2015). Embracing more transdisciplinary and multidimensional approaches is imperative for achieving sustainable outcomes in CBLRR.

vii) Exit strategies should be carefully considered in CBLRR efforts

In many of the cases studied, a key challenge emerged regarding the continuation, maintenance, and repair of CBLRR measures once the project funding ends (Hostettler et al., 2019; Klimeš et al., 2019). Drawing on the lessons from the studies in the Caribbean (see, for example, Anderson & Holcombe, 2006; Holcombe et al., 2012); Bangladesh (see, for example, Ahammad, 2011); and Nepal (see, for example, Malakar, 2014) amongst others, the practical lesson to be learned is that DRR programs, if embedded in the development process or delivered through the within-government institutional structure, particularly at the local level, increases the possibility of continuity, sustainability, and replication. Moreover, investing in education and involvement of new generations could also be a good long-term strategy as children and youths of today will become the decision-makers and change-makers in the future (Petterson, Wangchuk, et al., 2020; Ruiz-Cortés & Alcántara-Ayala, 2020).

Likewise, Scolobig et al. (2016) emphasized the importance of careful analysis of stakeholders' perspectives on causes and solutions of landslides. They advocated for the adoption of 'compromise' solutions to foster ownership over the activities by ensuring that each stakeholder gets more of what they desire and less of what they do not desire. Additionally, many reviewed cases have highlighted the positive contribution of community-level committees in planning and implementing CBLRR measures. However, as highlighted by Gladfelter (2018), the community-based projects should extend beyond enhancing the individualized capacity to be self-secure form disasters towards empowering communities to influence socio-economic systems that shape resource distributions. Only by empowering the community-based committees, the likelihood of continuity of CBLRR efforts beyond the project duration is enhanced.

Chapter 5 Living and dealing with landslides in Sindhupalchok: Mapping local knowledge and strategies in the context of the federal decentralising era in Nepal

An abridged version of this chapter is in review for inclusion as a book chapter in the Routledge *Handbook of the Himalayas* edited by Ben Campbell, Mary Cameron and Tanka B. Subba. Full copy of the latest version of manuscript is included in Appendix 8.

5.1 Overview

This chapter attempts to understand the underlying causes and consequences of 'everyday' landslides on Tamang people of Sindhupalchok. Using a political ecology approach, I argue that landslide risks are not only associated with the physical aspects like geology or rainfall, but also relate to political and socio-economic dimensions. Despite many socio-political transformations in Nepal, residents experience either no or only very little progress in terms of DRR. Marginalized groups like Tamangs continue to be deprived of access to decision-making and decision-makers. Recent federal transformations in Nepal have failed to acknowledge indigenous governance systems that held crucial significance in people's day-to-day lives, including precautionary landslide risk reduction efforts. Findings also highlight that everyday landslides can cumulatively accrue damage comparable to a large-scale event. However, such small-scale events are often neglected by the authorities, causing further impediment to marginalized groups. This chapter shines a light on local people's coping and adaptation practices and highlights how these practices are negatively affected by the changing socio-economic context of rural livelihoods.

5.2 Introduction

"*Kata dar nalagnu ni, jata tatai siyo ko tuppo jasto ho. Barkhamaa kei bhanna sakinna* (We are so afraid. Everywhere is like the tip of needle. What can happen in the monsoon we cannot say)," shared a frustrated 51-year-old man from Sindhupalchok, "Landslides have become so frequent after the 2015 earthquake and haphazard road construction through the village[12]." Based on ethnographic fieldwork conducted between May 2021 and October 2022 in the Tamang village Mathillo Sigarche—a 'category 2' geohazard risk settlement of Nepal's Sindhupalchok District, this study forefronts the day-to-day experience of living with landslides among the Tamangs—one of the largest ethnic minorities in Nepal[13] (Ghale, 2015; Tamang, 1992). Although research has highlighted disaster as a function of socio-political processes (Gould et al., 2016; O'Keefe et al., 1976; Oliver-Smith, 1996, 2016), marginalized groups like Tamangs are often deemed complicit in creating the conditions for their own disaster vulnerabilities (Blaikie, 1985; Eckholm, 1975; Ives & Messerli, 1989). Following a *political ecology* approach (Aboagye, 2012; Collins, 2008; Donner, 2007; Wescoat Jr., 2015) to explore 'everyday' landslide hazard and risks, my aim is to explore the perceived chains of causation and consequences related to landslides. In doing so, this study shifts attention from 'outcome vulnerability' to 'contextual vulnerability' for Disaster Risk Reduction (DRR) policies and practice to be effective (O'Brien et al., 2007; Oven et al., 2019).

In the recent years, studies on the synthesis of LK into DRR are increasing (Vasileiou et al., 2022) but remain less common in low- to middle-income countries like Nepal (Hadlos et al., 2022). Disaster-relevant LK in the context of historically marginalized groups, like the Tamangs, is often overlooked. Using ethnographic approaches, this chapter explores the rich but underrepresented capacities and strategies of the Tamang to live in adverse and unstable conditions, which connect with broader issues of socio-political transformations while living and dealing with disasters.

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[12] Nepal experiences a rapid escalation in rural road construction. Statistics show the growth of rural road network from 2662 km in 1995 (Bhandari et al., 2012) to 57,632 km in 2016 (DoLIDAR, 2016). The trends are believed to have further increased after the first local levels elections in 2017 in nearly two decades.

[13] Government of Nepal (Nepal Reconstruction Authority) had categorised the 2015 Gorkha earthquake affected settlements into three categories of geo-hazards' risks: Category 1, 2 and 3. Category 1 refers to safer communities. Category 2 refers to households/settlements whose shelters and/or livelihoods are unsafe due to existing state of geohazards, but the risks can be mitigated following appropriate measures. Category 3 refers to very unsafe settlements and are recommended for relocation because of the higher risks of geohazards that are extremely difficult to control for technical and financial reasons.

The research area, Mathillo Sigarche, experiences numerous small-scale landslides (< ca. 100 m in length) often not considered sufficiently impactful to warrant attention by donors, government and the media (Ritu, 2020; Shrestha & Gaillard, 2013). Therefore, I aim to unveil the ways in which Tamangs of Mathillo Sigarche deal with such *silent* or *neglected disasters* (Wisner & Gaillard, 2009). Such an understanding is necessary in having a comprehensive picture of the causes and impacts of disaster, particularly where the net impacts of numerous smaller events take the greatest toll.

This chapter begins with a brief overview and background of the chapter. Subsequent sections outline the findings and reflections drawn from this work.

5.3 Findings from the study

Ethnographic methods such as participant observation, informal conversation, and semi structured interviews were used for data collection (Bryman, 2004; Hammersley & Atkinson, 2019). The qualitative data analysis software NVivo12 (Lumivero, 2017) was used to categorize the findings of the ethnographic work into different themes and sub-themes. The crosscutting theme ***Tenants on own land*** will be introduced first, providing the context of the case study location. Other themes will be introduced thereafter.

5.3.1 Crosscutting theme 1: Tenants on own land

Much has been written about how Gorkha conquest dispossessed and reallocated productive lands among Gorkhali soldiers, *jagirdaars* (office bearers) and other clients in the form of *jagir*[14], *birta*[15], *rajya*[16] and *guthi*[17] systems (see, for example, Clarke, 1979; Regmi, 1999; Tamang, 2008). Such state-led strategies pushed ethnic groups such as the Tamangs into marginal lands (Mahat et al., 1986). The imposition of excessive taxes and forced labour worsened their situation (Holmberg et al., 1999) pushing them to take loans from

[14] Land assigned to government employees as emoluments; abolished in 1951

[15] Land expropriated from local population by the state to allocate to remunerate courtiers on tax-free basis

[16] Land given to the rulers in the defeated principalities by the state during Gorkha conquest

[17] Land endowed for any religious or charitable purposes

entrepreneurial Brahman and Chhetri families, or merchant Newars, often with exorbitant interest rates (Caplan, 1970; Höfer, 1979; Tamang, 2008). In my study area, many residents recite similar stories of land dispossession from their own experience or oral history from their ancestors.

"They gave us *Kuheko chamal* (rotten rice), *Kuheko kodo* (rotten millet), *Kira pareko makai ko chyakhla* (corn ground with bugs), *Mareko bakhra, gaai-goru haru* (dead goats and cows) and sometimes loans during our parents' tough times. Our fathers accepted those to raise us. In return they robbed our land," sighed a 50+ aged woman. During our conversation she was grazing her goats on the fallow land that used to be *bari*[18] until the 2015 Gorkha earthquake. Her weathered hands and wrinkled face spoke more than her words about generations of hardship and deprivation.

These stories of losing land to merchants/money lenders correspond to what Rankin (2004) referred to as 'killing the poor'. More than 90% of the people of Mathillo Sigarche who I talked to mentioned that their land now belonged to Newar moneylenders, and they now farm on a crop sharing basis. Borrowing anything from the merchants was a trap their ancestors could never escape from; interest rates were very high and often the amounts borrowed were manipulated, taking advantage of villagers' illiteracy. They worked hard, spent a much time patrolling crops against monkeys and porcupines, but had to carry at least half of the yield to the merchant's house in the nearby market area, nearly two hours away on foot. This imposed further stress on the already food insecure Tamangs. Almost all the informants mentioned that the produce remaining after sharing with merchants was inadequate to feed the family for more than a few months. Consequently, for generations they supplemented the diet with cattle rearing, eating wild vegetables, and working seasonally as porters and labourers in agriculture, road construction, hydropower, and stone quarrying.

[18] Dry upland terrace not suitable for paddy plantation.

5.3.2 Landslide impacts

The previous section discussed how my research participants lived as dispossessed on their ancestral land. The next few sub-sections consider the various impacts of landslides on lives and livelihoods.

5.3.2.1 Deaths, injuries, and psychological impacts

Sita Maya Tamang[19], who lost her seven natal family members, including her parents, in the 2020 Jambu[20] landslide, laments she is living a cursed life. She shared how her nephew who survived by holding the wires of gabion blocks for a whole night is still in trauma:

"Everyone is gone. My nephew was unrecognizable when the neighbours rescued him. His body was covered in wounds and mud. Had the helicopter not rescued him to the hospital in time, he might also have died. Seven family members were lost. Not a single body was found, and funerals were performed using dummy bodies. My nephew behaved like a person who lost his mind for several months." (Sita Maya, Female, 44, Personal Conversation, 2022)

While Sita's case represents an extreme landslide event severe enough to be recorded in official records, I met three other families during my fieldwork who have had at least one member injured or dead due to landslides within the village. Two cases of injuries had occurred while trying to move to a safer location during the monsoon immediately following the 2015 earthquakes, and one person died in 2002 while trying to untether his cattle after heavy rainfall and a landslide began. However, information about these events were unavailable in the government's database.

5.3.2.2 Damage to property and disruption of livelihood

It was not unexpected to many local families who rebuilt their houses after the 2015 Gorkha earthquakes on cracked terraces and close to stream channels were later affected by

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[19] Pseudonyms have been used throughout the chapter for research participants to hide their identity.

[20] Jambu landslide that had occurred downhill adjoining the Araniko Highway but in the same ward where my fieldwork is concentrated caused 2 deaths, 17 missing (assumed as dead), 5 injured and at least 15 houses completely damaged (MoHA, 2022b). However, the sources of debris were uphill from the spot of damage and include areas close to my fieldwork sites (Rosser et al., 2021).

landslides. A seeming 'ignorance' of people, however, is not always about absence of knowledge (Pigg, 1992). Instead, choices are based on rational comparison of risks, needs, opportunities and available options (Barclay et al., 2019; Johnson et al., 1982; Oven & Rigg, 2015):

"We were not sure if we should rebuild in the village, but in the absence of alternatives, and due to continuous push from the reconstruction authority to complete the housing reconstruction soon, we rebuilt our houses here." (Bire Tamang, Male, 68 years, Personal Conversation, 2021)

In seven years after 2015 Gorkha earthquake, three households had to rebuild their houses in other locations due to the repeated incidence of landslides, adding further financial stress. Landslides also badly impact crops and agricultural land. In 2020 and 2021, more than 20 *ropanis*[21] of land were covered with landslide debris and no compensation from local government and other agencies was received:

"Almost each year, the landslides damage my farm and crops. In 2020, I could not harvest even a single cob (ghoga) of maize. … I had to invest around 80,000 NRs. to clear the debris that year[22]." (Surya Lama, Male, 51 years, Personal Conversation, 2021)

Purna Bahadur shared how he and his family narrowly escaped death in a landslide on 8th July 2020. This was on same day as the Jambu landslide. The landslide completely damaged his single storied tin-roofed part of his home used as a kitchen and for storing grain. It also severely damaged his adjoining concrete house and fields above. However, when I visited the village just one year after the incident happened, it felt like it had never happened. His family had re-terraced the fields and recycled the materials from the damaged buildings to add another storey to the concrete house:

"…I was roused in the middle of the night hearing thunderous sounds outside. When I opened the door to check outside, I found wet mud and stones falling off the roof…. I screamed to wake

[21] 1 hectare=19.65 ropanis

[22] Around 615 USD at exchange rate of 1USD=~130 NRs. This implies that Surya's family had to invest nearly half of the average per capita Gross Domestic Product value of Nepal (The World Bank, 2024).

my wife and children…we were up to our knees in mud and debris while we carried our children to our neighbour's house some 100 meters away. It felt like we were not going to survive." (Purna Bahadur Tamang, Male, 32 years, Personal Conversation, 2021)

When I tried to find this landslide event in the government's database, it was not there. Even for bigger events such as the Jambu landslide which are recorded, no record of the ongoing psychological trauma experienced by surviving family members is made. Gaillard (2022a) compares such emphasis given to the universal ways of quantifying and comparing the impacts of 'extra-ordinary' disaster events to 'the quest for pantometry'. Such pursuit overlooks the impacts of many small-to-medium scale disasters, including the intangible effects of disasters of any scale.

5.3.2.3 Difficulties to commute to schools and concentrate in studies

There is only a lower secondary level school in the village. Students of secondary level and above must walk past multiple landslides and narrow trails for at least 90 minutes each way to reach the school in Barhabise *bazaar*. During my study period, there were about 20 students who had joined schools in the *bazaar.* Many of them mentioned that they choose to skip classes during heavy rainfall for difficulties to travel and for fear of landslides or slipping down. Those who could afford, rented shared rooms at the *bazaar* to attend school during monsoon. Almost all the current and former students, who went to the school at the *bazaar* mentioned of facing racist and derogatory comments from peers and some teachers. According to my participants, to date only about 15 people have passed secondary level school education. Many of those who attended schools—either in the village or in nearby *bazaar*—reported of the struggle to concentrate on their studies due to hardships they and their families had in dealing with rainfall and the threat and impacts of landslides.

5.3.3 Local knowledge of landslide risks and risk reduction measures

In the preceding section and sub-sections, I explored how the smaller repetitive landslides can cause detrimental impacts on people's lives and livelihoods comparable to larger landslides. In the following sections, I will delve into the people's perceptions about landslide causes, and their efforts to reduce the landslide risks.

5.3.3.1 Local knowledge of the landslide causes

Local people mentioned about the supernatural, natural, and anthropogenic factors as causes of landslides. Most elderly participants and ritual practitioners, like *Bombos*[23] and Lamas[24], believe that landslides can occur due to the anger of gods and deities (*Yul-lha*[25]), in response to immoral activities, or when people pollute sacred sites:

"I think the landslides occur when the territorial deities leave their place after the increase in greed and sins in the locality……. People started slaughtering cows and oxen... People also killed Naag (snake god)…. What can we expect after such sins?" (Bir Bahadur Tamang, Male (Bombo), 29 years, Personal Conversation, 2022)

I was surprised and confused to hear a Tamang *Bombo* mentioning butchering of cows as immoral and sinful, and a potential cause of landslides. Elsewhere I had heard about Tamang beef-eating as a major cause for their oppression by the state (see, for example, Tamang, 2008; Tamang, 1992).

For my clarification, I further asked him: *"Don't Tamangs eat beef from early on? I had heard that Tamangs do."*

He responded: *"Our ancestors ate …but only the ones that died naturally or in accidents, like, falling off the slope. But people even killed a pregnant cow causing dip (ritual pollution) to the territorial deities. Therefore, the deity left the place in anger and is punishing the people in the form of disasters. These landslides we are facing are nothing. There will be bigger and more severe landslides in future."*

Similarly, a female informant identified increased greed and intra-clan marriage as angering the gods. Whilst the precise descriptions differ, the underlying idea remains similar: elderly people, Bombos and Lamas generally believed in a 'sentient ecology' (Campbell, 2019) of responsive connection with the non-human, such that disasters like landslides and hailstorms,

[23] Tamang shamanic ritual practitioners

[24] Buddhist priests

[25] Territorial deities; Earth divinities

or misfortunes like slipping or being attacked by a leopard, are caused by territorial gods and spirits if people fail to please them through ritual offerings and moral behaviour.

However, youths generally held different explanations. They considered that landslides occurred as a combined effect of earthquakes, rainfall, and haphazard road construction. Road construction initiated in 2015 overlapped with the 2015 Gorkha earthquake and was conducted without adequate consultation with local people and environmental protection measures[26]. The earthquake triggered landslides on slopes already weakened by excavators, and further weakened when the dozers returned in subsequent years to rebuild the road:

"Had the dozer been not operated in 2016 again, probably the landslide would not have been reactivated. The earthquake and road construction had weakened the slopes." (Nabin Tamang, Male, 28 years, Personal Conversation, 2021)

"Didn't the villagers protest?" I asked. His reply was as follows:

"We did but they brought the dozers during monsoon when most of the villagers are busy transplanting millet and paddy. They even operated dozers at night when the local people were too tired to do anything due to intensive and continuous involvement in plantation… Instead, they tagged us as being anti-development."

Roads intended to bring socio-economic opportunities were not built in a risk sensitive manner (Lennartz, 2013). Consequently, they caused chronic losses for villagers, with recurrent damages, most commonly by disregarding valid local concerns and lessons from previous incidents (Huber et al., 2017).

Many local people demonstrated clear understanding of the interrelationship between haphazard road construction, earthquakes, rainfall, and surface water triggering landslides. For example, Bire, Surya and others explained that the culvert constructed along the most problematic section of the road was too small for run-off during monsoon and instead acted as a dam. Accumulated water later burst from the road section, and over the adjoining slopes

[26] Nepal had its local level elections almost after 20 years in 2017. In absence of elected local representatives, the local level planning and budgeting were largely influenced by ward citizen forums and ward secretaries, and were not considered transparent (Bownas and Bishokarma, 2019).

that had been weakened by the road construction and the earthquake. The outburst washed away gabion blocks used for slope stabilization and debris was dumped into streams and across fields and around houses. Many local inhabitants also highlighted clogging of traditional drainage canals as a cause of landslides in their village:

"Our ancestors cared about others, but these days people don't. They don't clean and maintain the drainages these days. Instead, they divert water from their field directly into the roads now. The surface water flows along the roads and trigger landslides in the weaker sections." (Surya Lama, Male, 51 years, Personal Conversation, 2021)

Indigenous drainage maintenance work was impacted due to multiple factors. For Bire and Surya, it was the decline in a feeling of care and responsibility towards the environment and other people, whereas for Purna Bahadur, a low-risk perception and lack of available labour led to less attention being paid to canal maintenance:

"My father used to cut drainage (kulo tarkaunu) before each monsoon to let the rainwater flow from field towards the nearby stream channel. However, I had stopped doing it because of lack of workforce in my family. Also, I did not think anything would happen until the landslide washed my field and house in 2020." (Purna Bahadur, Male, 32 years, Personal Conversation, 2021)

5.3.3.2 Local knowledge on landslide prediction

The appearance of unusual cracks on terraces and on courtyards (see Figure 5.1), the bulging of terrace walls and the (dis)appearances of springs were most mentioned indicators of landslides. Local peoples also mentioned of ants carrying eggs, unusual colours and sounds of the water in streams/gullies, tilting of trees/poles, stones falling, and hearing sounds of stone falling along gullies/channels as the indicators of impending landslides.

Figure 5.1: Examples of cracks observed in Mathillo Sigarche

It is noteworthy that Bir Bahadur, the *Bombo*, claimed he could predict rainfall and possible landslides by hearing the *dhyangro*[27] sound. According to him, the sound of *dhyangro* feels

[27] A two-sided drum made of deer/goat skin played by shamans in curing sick people and during festivals and auspicious occasions.

moist before rainfall as compared to other days. Many participants also considered the darkness and density of clouds as a means to predict rainfall and landslides.

5.3.3.3 Local early action, and landslide risk reduction strategies

The study found a diversity of early action and risk reduction strategies carried out by the local people to reduce landslide risks and losses, which are elaborated upon below.

5.3.3.3.1 Hazard reduction

As discussed by Oven (2009) in neighbouring Bhotekoshi Rural Municipality, people in my study area engaged in both religious and non-religious actions to manage landslide risks. Terracing, as practiced on most agricultural hillslopes worldwide, was the most common strategy to reduce instability. Inhabitants cut and/or clean drainage canals to manage rainwater away from their farm and reduce the landslide risk. Such activities are generally done annually before and during the early monsoon.

Another common strategy was the recutting of bulges, which are reinforced with masonry walls (see Figures 5.2 and 5.3). This is generally done during winter after the harvest and post-harvest works on crops like maize, millet and paddy are completed. Farmers wait until *Mangsir-Poush* (November-December) to repair slumps to avoid damage to standing crops. If the slump is small, family members manage it. Otherwise, neighbours are hired on daily wage or labour-exchange basis to undertake repairs. Such repairs are important to avoid slumps from turning into bigger slides. Similarly, resident families seal cracks and rat-holes by filling them with stones and mud to reduce water percolation. They believe that filling cracks and holes prevents further exacerbation of the problems.

Figure 5.2: A local resident working to reinforce terrace wall

Figure 5.3: Constructing walls like these is an arduous task

Farmers also try to prevent landslides by reducing crop intensity and changing the cropping pattern once land is perceived to be at risk of landslides. These strategies included planting maize and millet instead of paddy, or leaving land fallow for months or years when the risk is believed to be higher. Similar strategies were also adopted by the farmers of Nuwakot, a district lying northwest of Kathmandu Valley (Gurung, 1989).

When government or external funding is available, local residents invest in gabion boxes and tree planting on the sides of the gullies/stream channels to mitigate existing landslides. For example, in 2018 with an NGO's support, residents constructed ca.165 m^3 of gabions on the sides of *Pakhra Khola*[28] *(meaning Seto Dhedu*[29] *Khola in Nepali)* channel. However, the scheme lasted only a year and was washed away in 2020.

Participation in *Bhume Puja*[30] is another hazard reduction strategy. This ritual is performed twice annually—in May (Jestha Purnima[31]) and November (Mangsir Purnima)—to appease territorial deities for soil fertility, prosperity, good harvests, and protection of land from harsh weather and catastrophes including landslides (Smadja, 2009; Soden & Lord, 2018). Participation in such rituals also helps to reinforce community interrelationships—a social capital that could be used in communal activities. When villagers perceive increase in the risk of landslides, they consult the Bombo and Lama, and perform a religious ceremony to try to stabilize slopes. A local Lama (Surya) differentiated between the types of landslides that could be stabilized through such pujas:

"… The landslides that occur on its own can be stabilized by performing pujas to appease the deities…. We (Lamas) use twig of Titepati plant (Mugwort; Artemisia sps.) on two sides of the landslide and connect the twigs with threads at three points. We also spray Jhilap (holy liquid)

[28] Khola means Stream; River

[29] Seto Dhedu means Gray Langur in English

[30] Worship of the earth/soil that happens in Jestha (May) and Mangsir (November)—before the cropping and after the harvest of the crops.

[31] Purnima refers to full moon

over the unstable slopes …. No one should step on the site for 7 days after performing puja." (Surya Lama, Male, 51 years, Personal Conversation, 2021)

Interestingly, Surya considered the landslide affecting his land was triggered by road construction and would require engineered stabilization, reflecting multiple knowledge practices as reported by Bjønness (1986), Pilgrim (1999) and Sherry et al. (2018) amongst others. Bir Bahadur, the *bombo*, who had mentioned that landslides occur when the territorial deities leave because of sinful actions, claimed that landslides once initiated could not be stabilized because the deity would have already left. He further asserted that the *bombos* have power to bring the deity back, but forcefully doing so could harm and further anger them. Therefore, he suggested for abandoning sinful actions and performing ritualistic offerings as the most effective strategies to reduce the risks and mitigate the impacts.

5.3.3.3.2 Exposure reduction (temporary relocation)

Since the 2015 earthquake, as the monsoon progresses each year, at least 14 households temporarily stay at relatives' homes, nearby sheds, or in makeshift tarpaulin shelters on nearby public land because of the fear of landslides (see Figure 5.4). Staying in temporary shelters does not remove all risks though, as residents must still visit their houses and fields multiple times a day to check on and manage their cattle, assets, and crops/fields.

In households that stay put, a family member stays awake to monitor the gullies, channels, and slopes close by using a torch. When the risk seems increased, they waken other family members to move to safer areas. While moving, they also communicate their concerns to neighbouring households. Furthermore, some adopt measures to reduce exposure by refraining from unnecessary travel along unstable or narrow pathways during rainfall, limiting trips to shops, their fields, watermills, and schools, as well as minimizing visits to relatives. Together, these measures reduce people's exposure to possible landslides.

Figure 5.4: Part of goat sheds (goths) used as temporary shelter during monsoon

5.3.3.3.3 Knowledge transfer

Local people mentioned that knowledge about landslides, early indicators, their history, and ways to reduce hazard and exposure are generally passed on from older to younger family members. Knowledge sharing also takes place informally between extended families, neighbours and peers while grazing, celebrating festivals, rituals, and ceremonies, and in meetings of cooperatives and users' committees. Planting and harvest time is a good opportunity for discussing landslide issues and strategies when families and villagers work closely together. However, the recent disengagement of younger generations in agriculture, increased outmigration, and the practice of sending children to schools inhibit such indigenous knowledge transfer.

Some informants highlighted that the collective performance of pujas to stabilize slopes helps to inform the wider community about potential landslide risks. The *dhyangro* played during the ceremony not only helps mediation with deities but also acts as an attention-grabbing means for engaging community members. Likewise, the use of prayer flags across unstable slopes after the puja helps to alert people to the sentient ecology. It warns people about landslide vulnerability and encourages them to be cautious while traversing along and interacting with those slopes.

5.3.3.4 Landslide response, recovery, and reconstruction strategies

Just as the local people were found using various strategies for risk reduction before landslides occur, my study found diverse strategies used to respond to and recover from landslides.

5.3.3.4.1 Response and early recovery

In the absence of more formal emergency services, local inhabitants are invariably the first responders to disasters that occur in Mathillo Sigarche. Community members help in moving the elderly, persons with disabilities, children, and cattle to safer locations. If someone is trapped by a landslide, residents try to conduct the rescue using simple hand tools (e.g., spade, hoe). In particular, young males help in recovering the dead, and people's valuables from landslides, whilst women tend to spend time supporting affected family members by consoling them and looking after their children and cattle. People with political connections request support for sending rescue authorities' team as required. However, persons who could lobby generally stay outside the village in nearby Barhabise Bazaar or in Kathmandu causing delays in state interventions.

5.3.3.4.2 Ghewa contributing to trauma recovery

For 49 days after the death of a Tamang, the Tamang household undertakes a series of ritual actions called *ghewa* to guide the souls of the deceased towards reincarnation (Soden & Lord, 2018). Failure to perform *ghewa* means the souls would remain as spirits, troubling family members and creating obstacles for them in fulfilling their aspirations (Khattri, 2021). This process involves both paternal clan and maternal clan members, which facilitates the renewal of social bonds in the support of the recovery of mourning family members (Holmberg, 1989). Relatives and visitors provide the cash and crops for the family members that is utilized to perform the death rituals and to cope with losses experienced (Tamang, 2011). *Ghewa*, as also highlighted in Soden & Lord (2018)'s study, was seen and reported in my research as one of the most important occasions for showing solidarity and care for family members and a way for metabolizing trauma and grief in case of deaths including the disaster related deaths in a family. Such practices serve as essential community-driven psychosocial interventions in many rural areas like Mathillo Sigarche, where access to trained frontline psychosocial service providers is limited or practically absent (Chase, 2021).

5.3.3.4.3 Repair of trails, roads, and water supplies

Local inhabitants get mobilised voluntarily to repair damaged trails and water supplies quickly after landslides occur. The most intensive repair of roads is done before Dashain (October) after the monsoon[32]. The costs to resume water supplies, such as replacing broken pipes, are divided amongst beneficiary community members. Following repeated impacts on the water supply, residents have recently started using poles to elevate the water pipelines across vulnerable slopes to reduce damage on the pipelines (see Figure 5.5).

Figure 5.5: Drinking waterpipes elevated to prevent damage on pipelines from slumps and landslides

[32] Dashain is the most auspicious and longest Hindu festival.

5.3.3.4.4 Repair of houses and farmland

While there are high levels of community collaboration in immediate disaster response and the recovery of public infrastructure like trails and water supplies, the repair of affected houses and farmland generally falls on individual affected households. Some take advantage of reciprocal labour exchange known as *parma*, but more recently this has largely been replaced by cash-based wage labour. People work hard on repairs to their terraces and houses and try to recycle recovered materials as much as possible:

"…It took two months for our family to clear debris off the house and field, and re-terrace our field." (Purna Bahadur, Male, 32 years, Personal Conversation, 2021)

Sarcastically, one of my participants compared the cost of repairing the field with the original cost of the land:

"It cost me around 70-80 thousand rupees (~540-615 USD) to reinforce the terrace walls constructed in stone. The expenditure is almost the cost of this land. I hope this will stabilize the field for some years." (Surya Lama, Male, 51 years, Personal Conversation, 2022)

Those who do not see value in repairs do nothing. In 2022, over 20 ropanis of land remained uncultivated due to high costs of restoring land or maintaining terraces. The extent of abandoned land would have been even greater if not for concerns about losing tenancy rights or facing the anger of *Bhumedevi,* the Land goddess, for leaving the land barren. However, with the ongoing trend of landslides impacting agricultural land and crops, coupled with the diminishing economic viability of farming due to issues like fertilizer shortages in nearby markets and crop raids by wild animals, villagers anticipate that more families will disengage from agriculture. Consequently, little attention will be given to early detection and repair of cracks in fields and bulges on terrace walls, as well as routine maintenance of the drainages and retaining walls on agricultural terraces, thereby increasing the risks of landslide initiation (Rautela, 2015, 2020).

Figure 5.6: Abandoned land which used to be maize field before

5.3.4 Cross-cutting theme 2: Erosion of Tamangs' traditional governance system

So far in this chapter, I have described the landslide impacts, and local knowledges about landslide and risk reduction. In this section, I discuss how the traditional governance system of the Tamangs, called the *Choho,* was weakened due to political-administrative change in Nepal, with consequences for local knowledge and risk reduction.

Traditionally, Tamangs in my study area were governed by their own customary laws and traditional institutions, including the Choho (village chief), Bombo (shamans/priests), Lama (religious leader), and Tamba (ritual specialist—historian—poet) (Parajuli et al., 2019). Amongst them, Chohos were the village heads whose primary role was to coordinate, regulate and develop the village and society (Tamang, 2008).

Choho regulated the use of forest, pasture, communal land and water resources (Parajuli et al., 2019). According to local informants, c*hoho* ensured the repair and maintenance of trails, roads, and drainages through local peoples' corvee labour, in addition to the performance of village rituals to please deities and spirits. This was viewed as ensuring a village's prosperity as well as was deemed important for avoiding disasters. This village institution has been repeatedly undermined by state-imposed governance systems since the Gorkha Conquest, till the present Federal-Republic era. In an adaptation for existence, traditional roles were merged with that of village chief during Panchayat government. However, the choho system completely disappeared in my study area at the start of multi-party democracy in 1990.

Residents claimed the disappearance of the Chohos left a leadership vacuum, diminishing communal activities important for reducing landslide risks. Activities like cleaning and repairing drainage were done under the Choho's leadership. Instead, today collective efforts are mostly response-focused rather than precautionary. For example, residents still assemble to clear debris and restore trails after a landslide, but proactive cleaning and repairing trials and drainage that could have prevented or mitigated the landslide are rarely undertaken. Most importantly, in previous times, residents commonly migrated seasonally within Nepal, and in some cases to India, returning to the village for labour intensive cropping and harvest seasons, when they would also engage in such communal efforts. With conflict-related overseas migration trends since the 2000s, there is a shortage of workforce to do such essential pre-disaster maintenance work.

5.4 Discussion

5.4.1 Local knowledge for landslide risk reduction

As summarized in Figure 5.7 below, the Tamang community of Mathillo Sigarche use a wide range of knowledges to live with landslides. These include oral information about previous events unavailable in official records, alongside both supernatural and natural interpretations of disaster causation, and means to mitigate risks and impacts. The findings illustrate how the impacts of recurring small-to-medium scale landslides may be less visible to '*outsiders*' but cumulatively can cause significant local impacts (Bull-Kamanga et al., 2003; Shrestha & Gaillard, 2013). Coping with recurrent landslides includes occasional injuries and deaths, and repetitive losses of agricultural land, crops, and houses. In food insecure areas such as this, damage to crops and agricultural land seriously impacts livelihoods. A major compounding factor is the disinterest of younger people in agriculture, linked often to outmigration for employment. Approximately one-in-three households had at least one family member migrated abroad in Malaysia or the Gulf for income generation. As a result, the process of knowledge transfer from older to younger people around landslide risk reduction during farming activities such as cultivation, weeding, and harvesting times is faltering. They take loans at annual compound interest rates up to 36%, to pay brokers and manpower agents (up to 250,000 NRs[33]). Consequently, a significant amount of time and income from foreign employment is utilized in paying off the interest and debt.

The dwindling population not only means only fewer young people available to respond to disasters but also places increased workloads on remaining women, children, and the elderly members of the household and community, reducing the time available for socialization, mutual assistance, and cultural activities. Many of the informants, mostly the elderlies and ritual practitioners, are also concerned about the decline in ritualistic offerings to territorial deities and spirits due to depopulation and consequent potential escalation of anger in the form of further disasters and misfortunes. Unfortunately, I do not have space to elaborate the costs and benefits of migration in the study area. For implication of outmigration on risks or risk reduction, see, for example, Rigg et al. (2016) and Rigg & Oven (2015) amongst others.

Secular and religious measures to reduce landslide risks seem insufficient due to the cumulative impacts of increased landslide incidence particularly after the 2015 Gorkha earthquakes. This situation is compounded by poorly engineered roads, limited drainage management, outmigration of younger people, a lessening of mutual help and labour exchange, and the demise of traditional local leadership such as the *Choho*.

[33] ~ 2000 USD

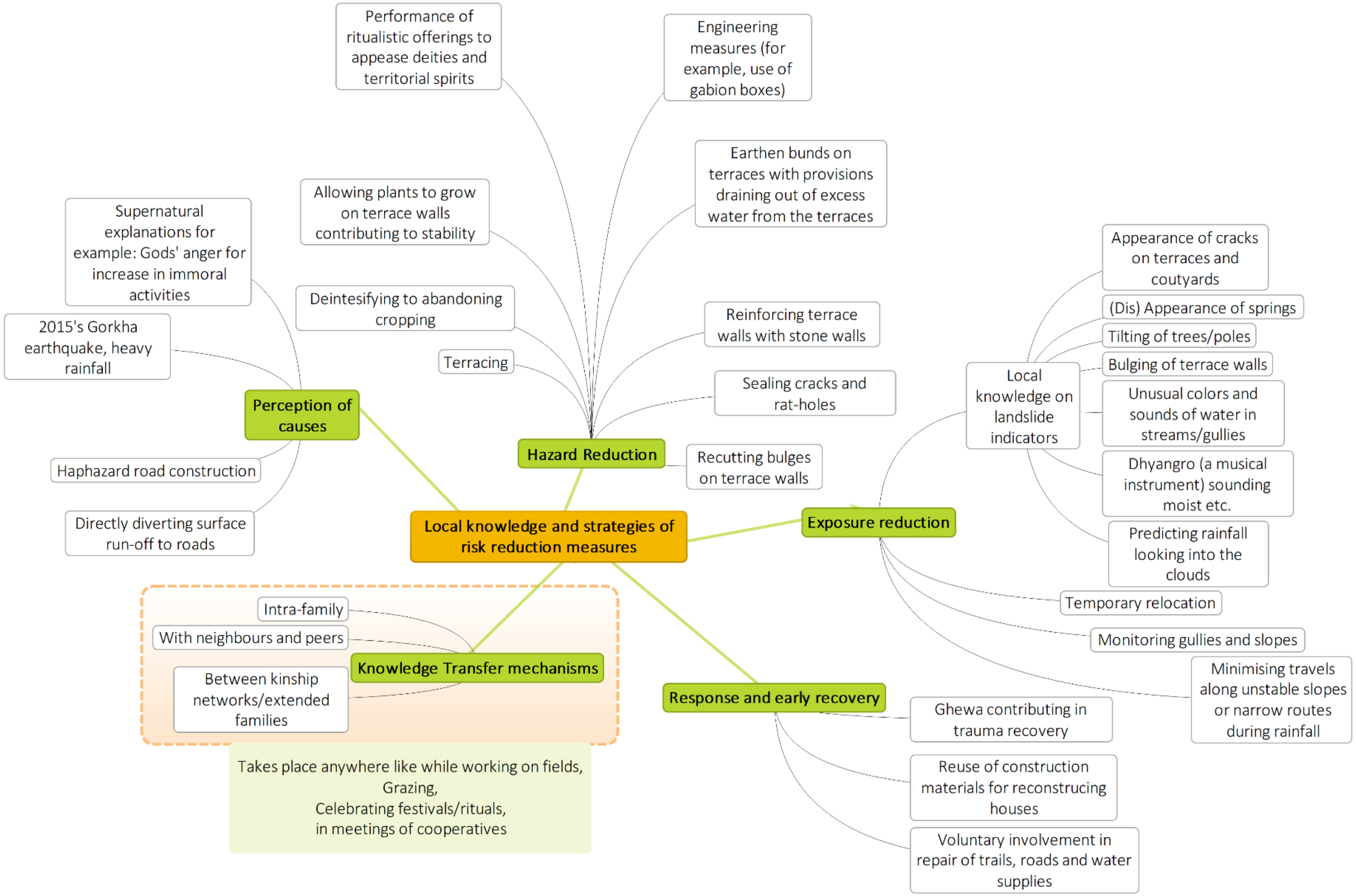


Figure 5.7: Key local knowledge and strategies used by people in Mathillo Sigarche

5.4.2 Continued exclusion in federally decentralized Nepal

The 2015's constitution transformed Nepal's governance into a federal system, with three tiers of government—federal, provincial and local (Nepal's Constitution, 2015; Khatri et al., 2022). Within this framework, the responsibility for disaster risk reduction has been mandated to all three tiers (Adhikari & Gautam, 2022; Disaster Risk Reduction and Management Act, 2017; Local Government Operation Act, 2017; Oxford Policy Management, 2020). However, most people believe that there has been negligible change regarding landslide risk reduction in their village. Residents have drawn attention of the ward authorities to the issues, but only received in response unfulfilled pledges to allocate budget for mitigation in the following year. Often, local people are deflected to higher authorities such as the Municipal, District Administration, Provincial and Federal Government offices, with nothing ever being done.

Conversations with elderly residents also reflected '*nostalgia'* (Simpson, 2005) for *Chohos,* describing how they would have mediated and facilitated follow-up between the villages and administrative representatives. Concerns are not being addressed. A 75-year-old Tamang, whilst not from my principal research site, whom I met in 2019 during my reconnaissance visit for study area selection mentioned "Raja le dekhdaina, mato le boldaina" meaning *the king (state) does not see and the land (that witnesses everything) does not speak.* I met him at a ward office with a petition from his village requesting either to stop ongoing road construction, or to do so by following proper environmental protection measures. His village of 150 households was at risk of landslides from construction. He was instructed to reach out to higher authorities by the ward which would require additional cost, effort, and time. *Gaau gaau maa Singha Durbar* is the slogan of Nepal's federal-republic era, meaning *every village is a power centre* but seems far from reality[34].

Despite restructuring DRR at local, provincial, and federal levels, there are no visible results for communities like in my study area. Local authorities continue to attribute landslides to a fatalistic combination of heavy rainfall and geology weakened by the 2015 earthquakes, masking the role of poor governance and haphazard development activities, indicative of

[34] A palace complex in Kathmandu, Nepal's capital, which holds different ministries and government offices. Singha Durbar term is used to infer administrative power centre.

‘strategic ignorance’ (Mcgoey, 2012). Significantly, damage due to small- and medium-scale landslides were not often officially recorded, rendering them ‘silent’ or ‘neglected’ disasters (Shrestha & Gaillard, 2013; Wisner & Gaillard, 2009). When the official recordkeeping misses the ‘silent’ disaster induced impacts and losses, the plans and policies formulated based on available official data is very unlikely to reflect the ground realities, greatly diminishing their chances of success (Rautela, 2016). Decentralization and overlapping roles of DRR are being used to pass on blame by concerned authorities masking inefficiencies and ineffectiveness (Maes et al., 2018, 2019). Local representatives claimed that decentralization of roles had not arrived with equally decentralized resources and capacity. Funds at ward level are recurrently spent on post-landslide road clearance, and ad-hoc relief after floods, fire and landslides, mirroring reluctance to shift from costly response-focused disaster management (Duda et al., 2020; Gaillard, 2022a). While the DRR professionals and authorities at national level are involved in developing guidelines, model laws and providing training, the toll of frequent ‘silent’ disasters continues to accumulate.

5.5 Conclusion

In this chapter, I presented a case study of Tamang community dealing with ‘everyday’ landslides that often escape the wider attention. I have shown that the degree of disaster vulnerability is more rooted in historical marginalization and resource extortion (Lama, 2022), rather than the severity of hazard itself (Wescoat Jr., 2015). Villagers use diverse knowledge and strategies to live with ‘everyday’ landslides, but such strategies are being eroded by increases in the scale and frequency of landslides in recent years, increased outmigration, and the demise of traditional community leadership roles. The study highlighted that small-to medium-scale hazards have the capacity to erode livelihood security and put immense psychological and economic stress on people.

The findings indicate that outmigration to escape the precarity associated with landlessness, deep-rooted poverty, and land and crop losses due to landslides and wild animals’ raiding, is doing little to reduce vulnerabilities. Conversely, outmigration is disrupting knowledge transfer and adding a significant workload on remaining women, children, and elderly.

Devolution of power alone is insufficient if not accompanied with capacity building and accountability mechanisms (Khatri et al., 2022). The study highlighted that the new local government is constrained in their ability to develop and implement DRR strategies and plans. Consequently, despite what are claimed to be progressive policy changes, emphasis in decision making is around infrastructure/roads construction, and post-disaster response and relief distribution, rather than in proactive risk reduction. Strategies should not be merely made based on the numbers of deaths, missing or injured but should be co-produced with affected communities (Gaillard, 2022a; Hewitt, 1997) which I suggest is currently absent in DRR plans at both local to national levels. A major adjustment in access to and control of land and resources will be required to address the contexts of vulnerability of indigenous groups like Tamangs.

Chapter 6 “Can slopes speak?” Context and process of setting up participatory landslide monitoring system in Sindhupalchok District of Nepal

6.1 Overview

This chapter explores the participatory landslide monitoring component of my research. The knowledge gaps that the participatory landslide monitoring aims to fill were iteratively identified using a combination of literature review, prior work experience in the sector, consultations with researchers, practitioners and stakeholders engaged in landslide risk reduction, and nearly yearlong ethnographic fieldwork. This chapter elucidates the background preparatory works, the issues and knowledge gap this research identifies and aims to address, and the process and nature of community participation during the co-design of participatory landslide monitoring and the installation of monitoring instruments. In the subsequent chapter, I will present the comprehensive analysis of the data collected by the monitoring systems and delve into the overall discussion and contribution of participatory landslide monitoring, and future avenues of collaborative knowledge production.

6.2 Introduction and background

Past studies (see, for example, Dahal, 2012; Oven, 2009; Petley et al., 2007) and my ethnographic study (see Chapter 5) underscore that many small-to-medium scale landslide events are not officially recorded, particularly when they occur in rural areas, and do not result in ‘sensationally visible’ impacts (Nixon, 2011) in terms of number of casualties and economic losses. Nevertheless, Chapter 5 highlights that such recurrent landslides can result in immense financial and psychological stress, and erode livelihood security and people’s trust in the authorities (Ritu, 2020). Such events fail to get the attention that their combined impacts deserve from public authorities and policy makers (Gaillard & Peek, 2019; Shrestha & Gaillard, 2013). Consequently, populations exposed to such chronic hazards are often reliant on their own adaptations and mitigations, drawing on a range of indigenous coping strategies (Cieslik et al., 2019; Johnson et al., 1982; Smadja, 2009; Sudmeier-Rieux et al., 2012).

Landslide risk reduction measures can be broadly classified into two main categories: i) structural, and ii) non-structural measures (Michoud et al., 2013; Pecoraro et al., 2018). A recent emphasis, building on participatory research notably around citizen science (Bonney et al., 2009), has been on the value of increasing knowledge and awareness through environmental monitoring. This also runs in parallel to recent enthusiasm around Landslide Early Warning System (LEWS) amongst researchers and decision makers (Guzzetti et al., 2020), primarily because of the opportunities brought about by the development of new technologies for landslide monitoring (Chae et al., 2017; Pecoraro et al., 2018), and the clear reductions in losses that warnings can enable. Furthermore, the international policy frameworks and agreements on disaster risk reduction, such as, Sendai Framework for Disaster Risk Reduction (2015-2030) and Early Warnings for All: Executive Action Plan (2023-2027) emphasize the importance of the increasing availability and access to multi-hazard early warning systems (UNDRR, 2015; WMO, 2022).

Landslide data and monitoring is a key component of LEWS (Piciullo et al., 2018). Monitoring may also be done to engender the shared understanding of the slope behaviour and associated risks (Chae et al., 2017; Hicks et al., 2019), particularly where such understandings are useful in identifying and planning mitigation and management options. To date, most LEWS use rainfall and thresholds to assess and evaluate the potential future failure of slopes (Michoud et al., 2013; Pecoraro et al., 2018). However, monitoring of rainfall only is known to result in considerable uncertainty (false and missed alarms) in landslide prediction (Gian et al., 2017; Michoud et al., 2013; Stähli et al., 2015). This is because besides rainfall, multiple often local predisposing, preparatory, and triggering factors determine if a landslide might occur or not (Crozier & Glade, 2005; Oven et al., 2017; Thapa & Adhikari, 2019).

With the advancement of technologies, the recent studies and LEWS are increasingly incorporating the monitoring of additional parameters such as groundwater and slope deformation conditions alongside rainfall monitoring to better understand the behaviour of landslides, and to improve the accuracy of the system (Calvello, 2017; Gamperl et al., 2023; Pecoraro et al., 2018). Equally, there is also a growing urge for 'first mile' approaches that put people at first in design and operation of the system (Marchezini et al., 2017). Such impetus for a bottom-up and participatory approaches to landslide monitoring and EWS echoes the overall recognition of the importance of participatory approaches in DRR sector arisen in response to the limitations of top-down approaches (Henriksen et al., 2018; Marchezini et al., 2018). Despite such push for participatory approaches to DRR, the examples concerning the process and benefits of participatory landslide monitoring are limited (Marchezini et al., 2018). This chapter reports the combination of ethnographic and geomorphological approaches that were used in my research to co-produce novel ways of monitoring landslides with the overall aim of contributing to LRR. I detail how the knowledges of what Lane et al. (2011) call 'certified' and 'uncertified' expertise were blended in knowledge co-production process.

The research discussed in this chapter followed eleven months of extensive ethnographic exploration of the local context and knowledge, as described in Chapter 3 and 5. Landslide monitoring sensors were installed in two stages during June-September 2022 along two slopes—one each—at Mathillo Sigarche and Tallo Sigarche where local people expressed concern about potential landslides. At Mathillo Sigarche, the slope monitoring was conducted in abandoned terraces above the village whereas at Tallo Sigarche, the monitoring was done on the slope above the local primary level school.

The fieldwork of my study had intersected with various phases of the COVID-19 pandemic, resulting in significant disruptions in research plan and activities and therefore, necessitated multiple adjustments to the research agenda, activities, and methods. Table 6.1 outlines the timeline of major activities related to preparing, planning, and implementing participatory landslide monitoring conducted in the field.

Table 6.1: Timeline of major activities conducted in the study areas

Description of major activities/Year-Month	2021									2022												2023					
	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
COVID-19 (Second wave) Delta Variant begins in Nepal																											
Initial onsite conversations with local residents and local stakeholders following COVID-19 safety protocols[35]																											
Ethnographic study following COVID-19 safety protocols[36]																											
Lockdown (Second wave) period																											
Monsoon season in Nepal																											
Lockdown (Second wave) lifted																											
Omicron Variant first appears in Nepal																											
Self-isolation for 8 days after being COVID-19 positive																											
Discussion on different landslide forecast and monitoring mechanism practiced globally and in Nepal										TS	MS																
Omicron variant effect continues in Nepal (Field work conducted following health safety measures)																											
Third wave of COVID-19 (Omicron variant) slows down																											
Discussion on the proposed landslide monitoring instruments and parameters																											
Discussion on the potential sites for landslide monitoring including joint site visits																											
Discussion on what local people would be interested to know through monitoring																											
Discussion on roles in participatory monitoring process																											
Meetings with potential drilling companies at Kathmandu																											

[35] I maintained informal conversations via virtual platforms with some local residents and other key informants since at least November 2020 during the initial COVID-19 phase and "work from home" mandates.

[36] Ethnographic work continued through the participatory landslide monitoring component of research

Description of major activities/Year-Month	2021									2022												2023					
	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Local Level Elections (Fieldwork was partly affected for ~ 5 days prior and 5 days after the election due to election and vote counting vibes)																											
Installation of weather stations at Mathillo and Tallo Sigarche																											
Drillings of boreholes and waveguides insertion (1st phase of AE installation)																											
Replacement of Hobo data loggers to ensure uninterrupted data collection																											
Acoustic Emission Sensor Installation (2nd phase of AE installation)																											
Technical problem arisen in Soil moisture sensor at 110 cm at Mathillo Sigarche																											
Return to UK for data analysis and writeup																											
Data analysis for Chapter 5 and preliminary analysis of Chapter 6																											
Replacement of soil moisture sensor at Tallo Sigarche at 80 cm depth																											
Replacement of soil moisture sensor at 110cm- Mathillo Sigarche																											
Preliminary findings sharing via face-to-face meetings and Youtube video																											

***Note**:* Final sharing of research findings was done on-site in March 2024. TS in the table indicates Tallo Sigarche and MS indicates Mathillo Sigarche. Similarly, different colours in the timeline indicates major categories as follows:

COVID timelines and associated impact
Monsoon/Local election/Technical issue
Research activities (both fieldwork and desk work)

This chapter is structured as follows: Sections 6.1 and 6.2 provide the overview and background to the study. Section 6.3 delineates the gaps in local and institutional knowledge concerning landslide risk and risk monitoring drawn from my ethnographic work, and the complementary literature. Sections 6.4 and 6.5 provide an overview of the background and preparatory works undertaken for executing participatory landslide monitoring work, including the process followed for selection of landslide monitoring sites. Sections 6.6 and 6.7 delve into the processes of installing monitoring instruments, downloading data, and implementing quality control measures for this study. Finally, Section 6.8 details the wider community engagement strategy followed in the participatory landslide monitoring and Section 6.9 summarizes the chapter.

6.3 Gaps in local and institutional knowledge about landslide monitoring for risk reduction

Building on Chapter 5, my objective in this section is to appraise the potential value of co-produced landslide monitoring as a means of addressing the gaps in local and institutional knowledge about landslide risk. Although these gaps are specific to my study area and Nepal as identified via my ethnographic study, literature review and past work experience, the insights gained are intended to be applicable to other similar landslide prone areas as well. I describe below seven primary gaps in knowledge and summarise the literature and my own ethnographic fieldwork that define these as necessary. In Chapter 7, I return to consider the degree to which the research that I have conducted has been or indeed could be successful in filling these gaps. Broadly these gaps encompass individuals' knowledge of their locality, knowledge of landslide processes upon and within a slope, the alignment of government endorsed mitigation measures to need, inconsistent understandings of the environment notably rainfall, the realities of EWS capabilities, and issues around trust.

i. Residents have a lesser understanding of landslides in areas outside their sight or regular interaction

Consistent with Basyal (2021)'s findings from the neighbouring Bhotekoshi Rural Municipality, my research participants also expressed their rich awareness of the changing landslide predictors and risks occurring in areas where they have regular interactions, such as, the fields, yards, and grazelands. However, they had less confidence in knowing what's happening in areas out of their observational reach or areas with less frequent interaction. Similarly, local residents had less confidence in being able to predict and respond to landslides occurring at night. Correspondingly, as highlighted in Chapter 5, every year since the 2015 Gorkha earthquake, at least 14 households temporarily reside on nearby public areas or in relatives' homes for part of the monsoon due to the fear of landslides that may initiate from the upslope abandoned terraces. Households that stay put often have a family member staying awake using torches to monitor gullies, stream channels and slopes. According to them, assessing the risks during the night remains very difficult due to poor visibility. During informal conversations, local people also mentioned the difficulties in evacuating to nearby safe locations during the night due to the risks of falling because of slippery or collapsed routes.

ii. Subsurface slope conditions are not well understood

Chapter 5 highlighted that the local residents considered cracks and fissures, bulging of terrace walls, tilting of trees and electricity poles in addition to unusual increases in the turbidity of springs as indicators of an increased risk of landslides. These forms of local anticipatory knowledge are mostly based on observations of surface features. These sit alongside a good understanding of the role of infiltration in increasing landslide risks and linked actions such as the practice of maintaining drains to divert excess surface water from fields and yards (Rautela, 2015). Conversely, as also expressed by respondents of Oven (2009)'s study from neighbouring Upper Bhotekoshi valley, many residents believed that the subsurface is resided by the snake gods, or *Naags* and that landslides occur when these gods leave in response to immoral activities, reflecting commonly held plural beliefs. Despite this, more 'technical knowledge' was often limited. For example, as also found by Basyal (2021) in nearby Bhotekoshi Rural Municipality, residents from Mathillo Sigarche and Tallo Sigarche were commonly not aware of the nature of underground geology (e.g., how deep the soil is, what type of rocks are nearby), or variable hydrological conditions. To enhance comprehension of the slope and landslide characteristics, monitoring both the surface and sub-surface parameters could be useful (Stumvoll et al., 2022).

iii. Current government advisories for landslides do not meet householders' and communities' needs

Most of the local residents in the study area were unaware of the existence of government advisories and weather forecasts from local and federal governments. Such information is commonly shared via social media (e.g., Facebook, Twitter) and websites. These products are designed to give the summary of hazard incidence and impact in the past 24 hours (see, for example, https://bipad.gov.np/en/communication_centers/detail/1439), or the general weather forecast for the next three days (see, for example, https://www.facebook.com/photo/?fbid=1294275101481572&set=a.367477954161296).

Some advisories also include a matrix based on the likelihood of occurrence and potential impacts. However, when I shared some examples of advisories, householders found it difficult to draw meaningful conclusions of relevance to themselves. For an example, a daily bulletin during the monsoon mentioned *"chances of medium rainfall at some locations and heavy rainfall at one to two locations".* Local residents considered this information too vague to relate to local contexts as they were unable to judge if their village should expect medium or heavy rainfall. It was also unclear what is considered as medium or heavy rainfall for any slope or location. For the local inhabitants in my study area, the generalized weather advisories remained hard to link to what to expect in their local contexts and hence, were deemed unhelpful. Similar issues were flagged by the majority of DRR practitioners working at district and national levels whom I had consulted and interviewed during my research. This is illustrated in the following quotation:

"People often don't have knowledge of the existence of such advisories. Even when some have, they find it hard to downscale the message to fit their local contexts." (A Field-based DRR practitioner, semi-structured interview, 2021)

iv. Perceptions of rainfall characteristics and slope deformation are inconsistent

While the local residents interviewed expressed a general commonality of understanding that landslides mostly occur during the monsoon, mirroring the seasonal distribution patterns of fatal landslides as shown by Petley et al. (2007), the perception and understanding about wider rainfall characteristics such as the onset and withdrawal of the monsoon, and the variability in the amount, duration, intensity, and frequency of rainfall was contested. Discrepancies in perception may reflect different experiences, beliefs, and misconceptions

(Calvello, 2017) or priorities. People often forget past events with the passage of time (Rautela & Pande, 2005). Research has shown that people over- or under- estimate hazards and risks based on their experience (Roder et al., 2016), the availability of protective measures and level of trust in authorities (Wachinger et al., 2013), the location, magnitude and frequency of hazards (Bjønness, 1986), belief in gods and supernatural powers (Cannon, 2015), economic circumstances (Alexander, 1992), physical abilities, social bonds and family values (Appleby-Arnold et al., 2018), place attachment and livelihood opportunities (Oven et al., 2021), or vested interests associated with property value (Nathan, 2008). Such influences on hazard and risk perception ultimately challenge decision making around disaster risk management.

v. Most landslide monitoring measures undertake rainfall monitoring only and do not monitor the precursors of landslides

Although the application of monitoring landslide deformation is growing (Michoud et al., 2013; Pecoraro et al., 2018), most local landslide EWS are based on empirical rainfall thresholds defined heuristically—based on opinion or practical experience of 'certified' experts (see, for example, Dikshit & Satyam, 2018; Kundalia et al., 2009; Malakar, 2014; Practical Action & Mercy Corps Nepal, 2012; Thapa et al., 2023). This causes considerable uncertainty in landslide prediction (Stähli et al., 2015). Many key informants, with prior or ongoing involvement in implementing rainfall threshold-based EWS in communities, underscored the issue of false alarms generated by the system, instigating a notable erosion of people's trust on the system's efficacy and worth:

"*While the early warning system (EWS) for riverine floods are well-established, those for landslides are not as developed. Certain organizations have piloted EWS based on rainfall thresholds, but they encountered significant inaccuracies." (A Kathmandu-based DRR professional, semi-structured interview, 2021)*

The monitoring of factors indicative of impending movement, such as deformation and ground water are not commonly considered (Pecoraro et al., 2018; Stähli et al., 2015) due to the complexity and cost, rather than proxies such as rainfall. To enhance the value and public uptake of monitoring and warning systems, it is important to improve the accuracy of prediction (Calvello, 2017; Dixon et al., 2022). Sherpa (2015), in discussing the early warning system for Imja Glacial Lake Outburst Flood (GLOF) in Nepal's Khumbu region, eloquently presents the consequences of false alarms and spread of rumours, particularly on the newborn babies and lactating mothers. Hence, to minimize such chances and consequences of false or missed alarms in landslide monitoring and EWS sector, past studies suggest that incorporating antecedent rainfall (Naidu et al., 2018), soil moisture conditions (Abraham et al., 2020), and measurement of deformation such as via acoustic signals (Deng et al., 2023; Dixon et al., 2022; Stähli et al., 2015) are helpful for improving site-specific landslides prediction with better accuracy and reliability.

vi. Local governments lack low-cost measures for landslide risk reduction

As discussed in Chapter 5, the LRR efforts by local government and CBDRR organizations are costly or response focused (Smith et al., 2022). In Nepal's context, the most common approaches promoted include the formation of disaster management committees and providing basic first aid and rescue training, provisioning first aid kits and rescue equipment, stockpiling and providing relief items to disaster affected, building emergency shelter houses, constructing bio-engineering measures, and constructing engineering measures most commonly the gabion walls (Khatri et al., 2015; Oven et al., 2017). These measures might not always be the most suitable and cost-effective measures to reduce landslide risk. Semi-structured interviews with representatives of DRR authorities, researchers and practitioners highlighted that a key reason for this is the lack of a cost-efficient approach that effectively helps to understand the slope behaviour and inform risk reduction and management planning. This study aims to fill the gap by coproducing new learning and evidence in the sector of low-cost landslide monitoring.

vii. Lack of trust in science and 'outsiders'

A crucial issue for knowledge co-production reported from previous research is the lack of trust between local and scientific communities (Gaillard & Mercer, 2012; Hermans et al., 2022). In many initial conversations, villagers repetitively satirized me saying that many people like me had come to the village before to ask about earthquakes and landslides, but they don't know what they have then done. Such frustrations indicate villagers' distrust of '*outsiders*'. Carefully executed participatory approaches to knowledge (co-)production have the potential to generate greater trust and ownership and contribute to enhancing the knowledge itself (Vasileiou et al., 2022). By drawing on the insights of Cooke & Kothari (2001) regarding the 'tyrannies' of participatory approaches, and embracing Callon (1999)'s Co-production of Knowledge Model (CKM) which recognises that expertise is widely distributed within society, thereby advocating for breaking down the hierarchies and borders between local people and researchers, this study seeks to bridge the divide between the 'local' and 'scientific' community to create shared knowledge and viewpoints about landslide monitoring and risk reduction.

6.4 Landslide knowledges as the basis for participatory monitoring

Prior to thinking about the landslide monitoring component of the research, eleven months of ethnographic engagement with the community members was undertaken. This engagement proved crucial for building trust, learning about the context and people, including gatekeepers and power dynamics, and gaining support for my research. During the initial phases of my research, talking to people informally (Swain & King, 2022) whilst walking to or from the village, resting at shops or *chautaris* (rest stops usually with a raised platform around a tree trunk), waiting at the ward office, or working in fields, on roads or grazing cattle were crucial in building rapport. As explained in Chapter 3 and 5, I developed my research using participant observation through political ecology and cultural lenses to learn about landslide impacts and evolving local knowledges used to live and deal with landslide risks. During the process, a series of informal and semi-formal meetings and discussions were also held to gather the information presented for Chapter 5 and to set-up the environment for the participatory action research component of my research presented in this chapter and the subsequent chapter. Local authorities and elected representatives were regularly updated about my plans and outcomes of my work. In some discussions, they were invited to participate, observe, and provide their input and insight.

During the ethnographic study, the initial one-to-one conversations and group meetings/discussions focused on the past occurrences, impacts and locations of landslides. Participants were asked about their ideas around the causes of landslides. These interactions proved crucial in learning about the locations, frequency of occurrence, and severity of landslides in everyday life. During the subsequent meetings and conversations, participants were asked to share their strategies to cope with and mitigate the landslide risks at individual, household and community levels. Interestingly, their strategies also included their own ways of examining early indicators for predicting landslides (see Section 5.3.3.2 under Chapter 5 for details about local knowledge on landslide prediction). As Table 6.2 suggests, local people of my study areas possessed a wealth of knowledge around the context of landslides, their occurrence and impacts that sat alongside more 'scientific' explanations suggesting a blurred boundary between the 'scientists', 'science' and 'people's science' or knowledges (Lane et al., 2011; Nygren, 1999).

Table 6.2: Shared concepts: People's science and actions, and scientists' science

'Uncertified' expertise	**'Certified' expertise**
Local knowledge of past small to medium landslides that are often missing from official records	Useful to address the challenges associated with the spatial and temporal resolution of satellite images and maps as well as incomplete official datasets about disasters and their impacts
Experiential knowledge that most landslides happen in monsoon, and are related to particular forms of rainfall	Seasonality of hazards and rainfall and the associated build-up of pore water pressures as one of the major triggering factors for landslides
Attribution to roads, earthquakes, lack of drainage maintenance and rainfall for increase in landslide incidences and risks	Role of predisposing, preparatory and triggering factors in causing landslides
Terracing to enable sustainable agriculture on slopes	Terracing, though primarily done to increase the area under agriculture, helps to reduce overall slope angle and helps to mitigate slope instability and landslides. Terraces also help to intercept precipitation and reduce surface runoff and erosion.
Earthen bunds around the outer edges of terraces with provisions of draining for excess water from the terraces to reduce topsoil erosion	Importance of managing surface water on steep slopes to mitigate soil erosion, preventing excessive stagnation of water for mitigating slope instability
Allowing trees to grow on the terrace walls to increase stability, while also meeting and complementing fodder and fuelwood needs	Related to reinforcing soil layers by binding and anchoring soils with plant roots: A basic form of 'bioengineering'.
Construction of stone masonry walls, or planting grasses at the edge of terraces to increase stability	Increasing slope strength by providing structural support to steep terrace walls
Unblocking drains and maintaining drainage channels before the monsoon	Importance of reducing water in slopes, and efficiently managing surface runoff

'Uncertified' expertise	'Certified' expertise
Removal of debris and the construction of walls on the sides of gullies to help water flow	Managing runoff and the reduction of gully erosion and bank cutting in channels.
Sealing cracks and filling in 'rat holes'	Importance of managing infiltration of water into the slope to help to reduce pore water pressure and effective stress which may destabilise the slope.
Removal and rebuilding of bulged portions of terrace walls	Identifying potentially unstable and moving slopes and rebuilding them prior to collapse
Predicting rainfall looking into the density, colour, and direction of movement of clouds	Different cloud formations, and their direction of travel (e.g., E – W versus S – N) generate different forms of rainfall, with different associated risks.
Water seeping out as a possible indicator of landslides	Indicator of ground saturation and increase in ground water table to the surface
Minimising unnecessary travel during and after intense or longer duration of steady rainfall as a strategy to reduce chances of encountering landslides	Exposure reduction at times of elevated risk
Temporary seasonal relocation	Strategy of exposure reduction
De-intensifying farming and changing crops. For example, planting maize or millet instead of paddy, and/or leaving the land fallow when the perceived risk levels are higher	Responsive cropping to minimise water infiltration and build-up of ground water and pore water pressure
Mixed cropping and intercropping to increase reliability of yield	Minimize losses due to insects and pests and weather stresses and to improve food security in resource deficient regions like the study area
Participants reported that "The culverts used are too small. They act as dams to surface run-off. They burst and even wash away the gabion boxes used to prevent gully erosion."	Engineered mitigation when not properly designed to cope with the magnitudes of events (e.g., flow volumes), the result is a compounding effect caused by backwater fill, water seeping from areas around culverts and promotion of concentrated flow and erosion, leading to the eventual collapse of the slope.

While findings from the discussions related to landslide impacts, and local knowledges to cope with and reduce landslide risks have been presented in detail in Chapter 5, this chapter presents the establishment of a participatory landslide monitoring system as a means of further exploring synergies between the different knowledges and the gaps that emerge, displayed in Section 6.3 and Table 6.2.

Meetings to explore local knowledges were followed by meetings where I shared my preliminary findings on community-based approaches to LRR. The approaches included different structural and non-structural examples about risk assessment, hazard reduction, exposure reduction and vulnerability reduction, amongst others (see Chapter 4 for details). In that meeting, I also shared about landslide forecasting and prediction methods—both site specific (Michoud et al., 2013) and territorial (Piciullo et al., 2018)—practiced in Nepal and beyond. From this meeting onwards, the discussions started getting more focused towards participatory landslide monitoring component of my research elaborated in detail in this chapter. However, it is worth mentioning that the information collection process informing Chapter 5 occurred concurrently and sometimes overlapped with the processes employed for participatory landslide monitoring component of my research.

During the discussions, I described the limitations of most LEWS based on rainfall thresholds, and other sources of risk information available in Nepal (Michoud et al., 2013; Pecoraro et al., 2018). The examples of the nearby Jure, Jambu, and Nagpuje Landslides—three of the most fatal landslides since 2010 that had occurred within the municipality where my study areas are located—proved a wise strategy to keep the participants interested in the discussion as the locations and incidents were familiar. These events were helpful to explain how relying on recent (the previous 24 hours) recorded rainfall at the nearest monitoring stations would not have been helpful in reducing losses as the rainfall recorded had not exceeded the threshold used for Nepal[37]. In talking about the Jambu landslide, I explained how the incidence of cloudbursts are expected to increase with climate change, and how such cloudburst events might not be recorded due to their highly localised nature and sparse scientific instrumentations (Lamichhane et al., 2021; Talchabhadel et al., 2021). I explored the degree to which participants are aware of sources of weather information, including the 3-day weather forecast and daily disaster bulletin published by the Nepal government. While few

[37] Department of Hydrology and Meteorology's website mentions rainfall amount of 60 mm in 1 hr, 80 mm in 3 hr, 100 mm in 6 hr, 120 mm in 12 hr and 140 mm in 24 hr as the warning level indicating the potential threat for landslides in steep slopes. These intensities are widely promoted as being warning levels for landslides by many NGOs working in disaster risk reduction sector in Nepal.

were aware of these updates on the radio, no one knew about the Nepal Government's daily disaster bulletins through Facebook or websites. As shared some samples of the government advisories, they were considered useful for raising general levels of caution, but many felt they were not helpful in making judgements as they did not represent locally specific information.

For me, this meeting was crucial in setting-up the momentum for participatory landslide monitoring. Importantly, by participating in this meeting, my participants understood the limitations of a sparse rain gauge network in capturing precipitation variability (Rautela & Karki, 2015; Talchabhadel et al., 2021), and so in the following meeting, I introduced the idea of research that involves monitoring an unstable slope of concern, measuring rainfall, soil moisture and acoustic emission sensors.

This proposal was not a complete surprise to the participants as I had been tentatively introducing the idea previously. Almost all welcomed the suggestion. However, some expressed interest in support with related issues such as in advocacy contending haphazard rural road construction, demanding compensation for landslide impacts on farmland, demanding budget from the local government and NGOs for construction of gabion and concrete retaining walls, demanding budget for upscaling culverts, and demanding budget for temporary shelter kits during monsoon.

In response I clearly explained that my research is to some extent constrained, but the landslide monitoring could directly or indirectly help across these issues by building an evidence base. We agreed to meet the following week to discuss further about the monitoring equipment, location, and approach. Those who wanted to focus on other issues gradually showed more interest in the proposed approach, as we also started approaching different NGOs, and ward and municipality offices with requests linked to addressing the issues that they had raised.

6.5 Setting up the participatory landslide monitoring

I held four more meetings at each study site with local research collaborators to discuss the monitoring instruments to be installed, agree on the roles during the research process, pinpoint what local residents would hope to learn from the landslide monitoring, and determine potential sites for the instrumentation. At Mathillo Sigarche, the local religious leaders such as *Bombo and Lama* and members of the 14 concerned households who practiced temporary relocation during periods of monsoon to nearby public lands in fear of landslides were involved. At Tallo Sigarche, as the local primary school's premises housed the monitoring site, members of the school management committee were primarily involved. Additionally, some individuals from the houses located close to the monitoring site were also involved.

In the first meeting, I started the discussion with an overview of different monitoring parameters, and instruments available for which I had taken references from my personal experience and the previous studies by Michoud et al. (2013), Pecoraro et al. (2018), Piciullo et al. (2018), Pradhan et al. (2020), Stähli et al. (2015) and Thapa & Adhikari (2019) amongst others. In the subsequent meeting, I proposed to use rainfall, soil moisture, temperature, and acoustic emission sensors and explained that the data collected by these sensors are expected to help us understand the links between rainfall, soil moisture and slope deformation. I customized the pictures from Pradhan (2021)'s thesis (see Figure 6.1) and Smith et al. (2014)'s paper (see Figure 6.2) to pictorially illustrate how the monitoring instruments tentatively look like and how they function (see Figure 6.3).

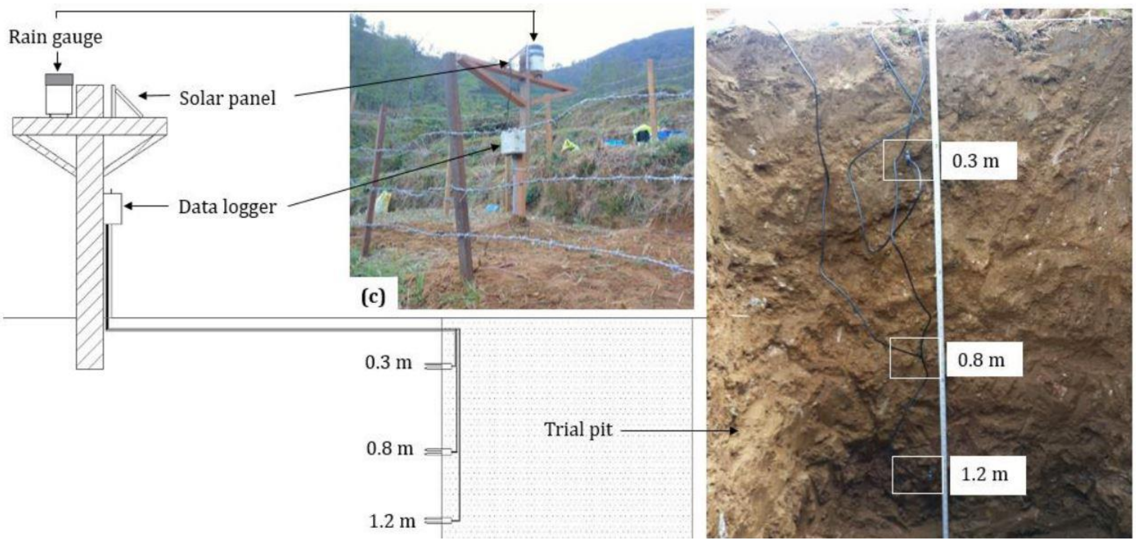


Figure 6.1: Schematic illustration of rainfall and soil moisture monitoring station sourced from Pradhan (2021, p. 126)

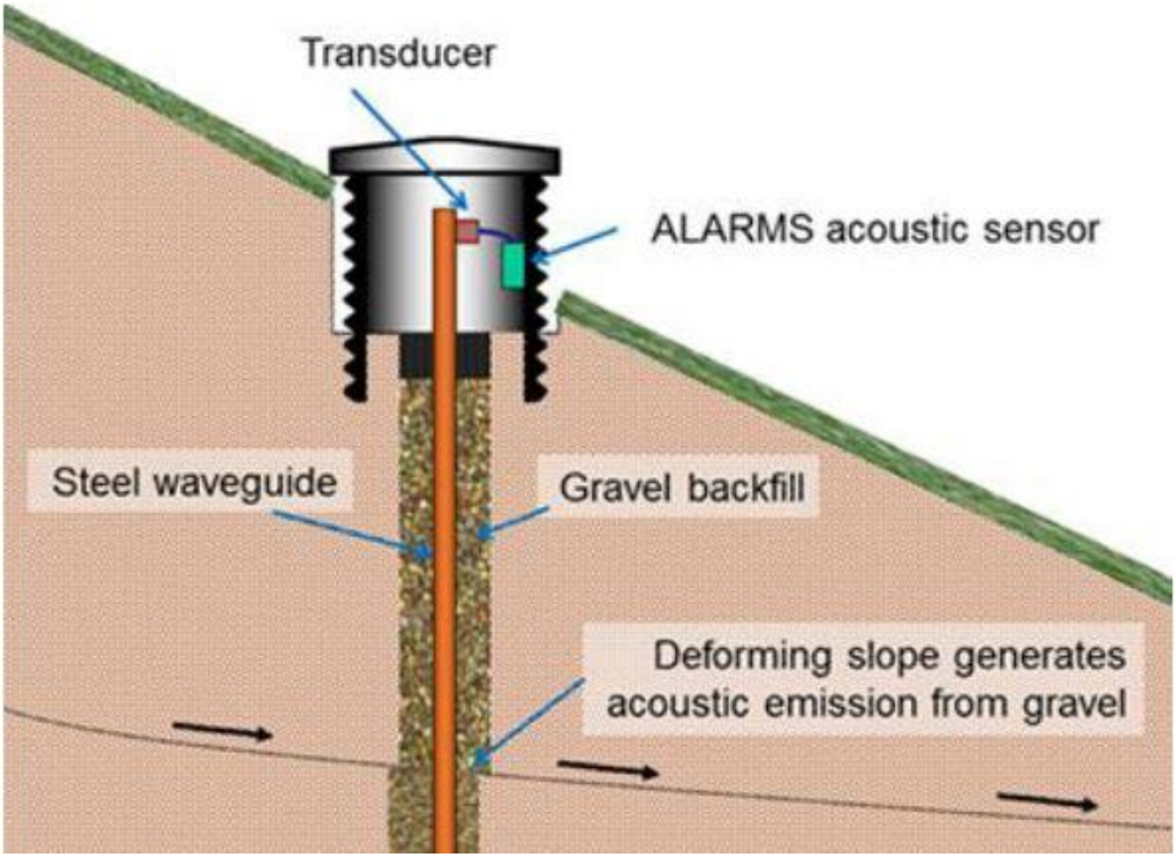


Figure 6.2: Schematic illustration of acoustic emission sensor sourced from Smith et al. (2014)

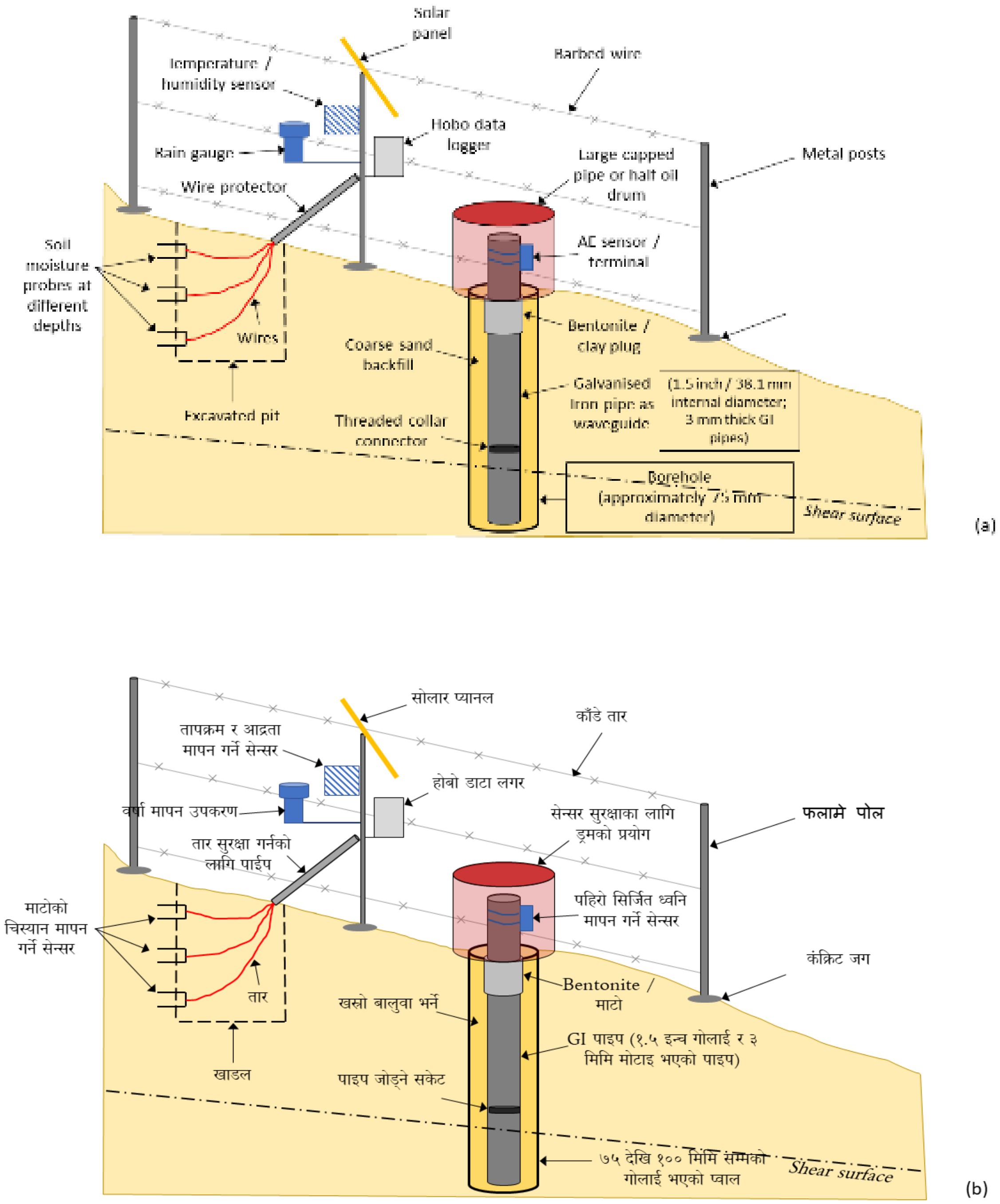


Figure 6.3: Schematic illustration in (a) English and (b) Nepali of weather and acoustic emission monitoring instruments for slope monitoring [modified after Pradhan (2021) *and* Smith et al. (2014)]

Pradhan (2021)'s findings on the patterns of rainfall and soil moisture at different depths were also used to explain what the sensors can generate [see Figure 6.4 for the picture sourced from Pradhan (2021)'s study]. I also shared that similar instruments were being installed as part of the Sajag-Nepal (https://www.sajag-nepal.org/) project at eight other locations across Nepal to gain a better and bigger picture of slope movement conditions (Sajag-Nepal, 2023).

I highlighted this as a good opportunity for knowledge generation and exchange as this type of monitoring had not been done before in Nepal to the best of our knowledge.

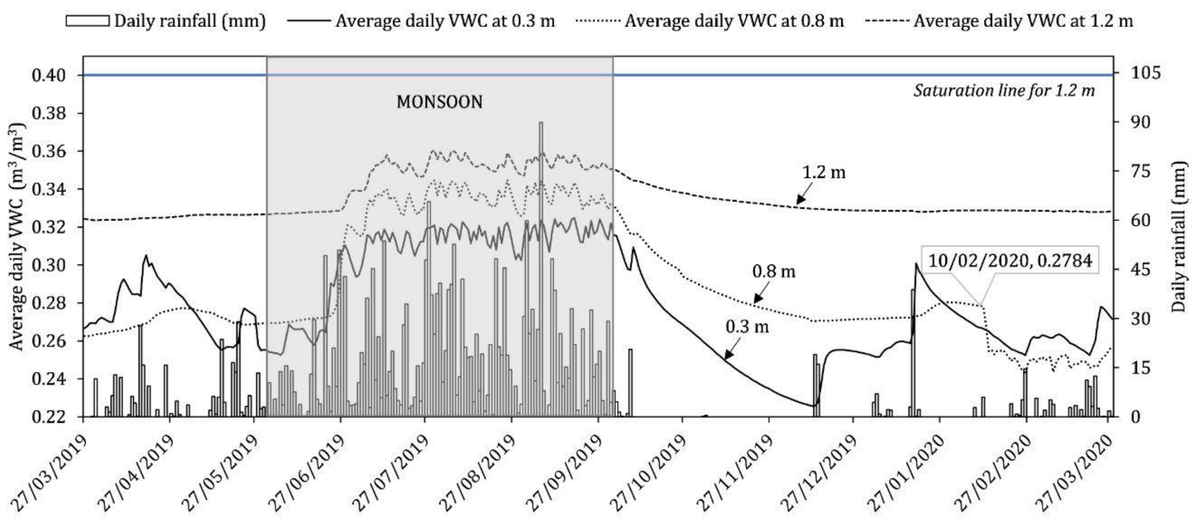


Figure 6.4: A visual representation extracted from Pradhan (2021)*'s study that showcases the trends in average daily volumetric water content and daily rainfall (p. 136)*

6.5.1 Monitoring parameters and instrument selection

The monitoring parameters and instruments were selected following a literature review, insights from personal experience and semi-structured interviews with experts and DRR practitioners with experience of landslide monitoring. Monitored parameters can be classified into four categories: i) deformation, ii) ground water, iii) triggers, and iv) predisposing factors (Calvello, 2017). Monitoring methods can be classified into six categories: i) geotechnical (measuring ground displacements, soil moisture, ground water level, and total stress in soil), ii) hydrologic (measuring distribution and movement of water on and below the surface), iii) geophysical (observing the physical parameters of soil or rock masses), iv) geodetic (measuring angles and distances, or tracing GPS signals to assess landslide displacement), v) remote sensing (monitoring surface displacements and other physical characteristics of a slope without making any physical contact with the slope), and vi) meteorological (measuring weather parameters such as precipitation, snowmelt etc. that may trigger landslide) (Pecoraro et al., 2018). Simplicity, redundancy, robustness, cost effectiveness, precision, and reliable communications and power supply are important conditions while selecting the landslide monitoring equipment (Dixon et al., 2022; Michoud et al., 2013; Pecoraro et al., 2018; Stähli et al., 2015). As previously noted, most LEWS implemented in Nepal are based on the empirical rainfall thresholds that triggered landslides in the past (Caine & Mool, 1982; JICA, 2009; Malakar, 2014; Practical Action & Mercy Corps Nepal, 2012). Equation 6.1 given below represents the empirical rainfall threshold based on 193 landslides that occurred from 1951 to 2006 in terms of rainfall intensity (I) in mm/hour, and rainfall duration (D) in hours (Dahal & Hasegawa, 2008):

$$I = 73.9D^{-0.79} \tag{6.1}$$

This relationship is widely used by DRR organizations in Nepal. However, such empirical thresholds might not be representative for a particular slope and may impact the credibility of LEWS due to false or missed alerts (Marino et al., 2020; Mercy Corps Nepal, 2016; Stähli et al., 2015). This was echoed by the key informants with experience in promoting rainfall threshold based EWS. Consequently, some researchers and organizations have tried to customize thresholds for specific localities. For instance, Thapa & Adhikari (2019) established a 24-hour rainfall threshold of 60 mm or more for the Mehele landslide in Dolakha District of Central Nepal. Likewise, Practical Action & Mercy Corps Nepal (2012) set a 24-hour rainfall threshold of 200 mm or more for their project sites in Kailali and Tanahun Districts. Similarly, Nepal's Department of Hydrology and Meteorology (DHM) promotes the 24-hour rainfall threshold of 140 mm or greater for potential landslides in steep slopes across Nepal (see, https://hydrology.gov.np/#/rainfall_watch?_k=r4tefl).

Although rainfall is a primary trigger of landslides in Nepal, the change in volumetric water content (VWC)[38] or pore water pressure are more reliable indicators of slope stability (Pradhan et al., 2020; Toll et al., 2011). Thapa & Adhikari (2019) used rainfall, soil moisture and extensometers to establish Local LEWS (Lo-LEWS) on the Mehele landslide in Dolakha's Sundrawati Village. Their study also highlighted the occurrence of a false alert, which was later rectified through physical examination by the system caretaker, underscoring the complexities of a landslide EWS. In 2017, I was involved in a Lo-LEWS pilot in Ramechhap District as a part of disaster preparedness project funded by European Commission Humanitarian Aid Department's Disaster Preparedness Programme, commonly abbreviated as DIPECHO

[38] Volumetric Water content is a method of measuring soil moisture content and is defined as the ratio of the volume of water to the unit volume of soil (Toková et al., 2019).

amongst the humanitarian and development agencies working in Nepal. The pilot was technically supported by researchers from Durham University's Department of Geography—two of whom are my current research supervisors (Nick and Katie), where we had tried to assess the relationship of rainfall, soil moisture and slope movement using an automatic system to measure rainfall and soil moisture levels, and involving local volunteers to manually measure the slope deformation by measuring the distance between the wooden posts distributed across a landslide prone slope.

To better understand a landslide, it's important to monitor the combination of both surface and sub-surface parameters (Stumvoll et al., 2022). My list of useful monitoring parameters included the measurement of acoustic emissions (high frequency noise) generated during slope deformation (Smith & Dixon, 2018). Such acoustic emissions could reflect precursors of slope failure (Stähli et al., 2015) and have been trialled in Myanmar (Dixon et al., 2022), Malaysia (Dixon et al., 2018) and UK (Dixon, Smith, et al., 2015), amongst others. Studies suggest that the acoustic emissions (AE) can be used to detect the changes in rates of slope movement, if not direct measurements of velocity (Berg et al., 2018; Dixon, Smith, et al., 2015). Put simply, AE are high frequency elastic stress waves generated by the deformation of materials (Dixon et al., 2018; Smith et al., 2020) and are sensitive to small magnitudes and slow rates of displacement (Smith et al., 2014). I was attracted to using AE sensors because this seemed a new and promising approach for Nepal, especially with the manufacturers having simplified the sensors and lowered the costs in recent years (Dixon et al., 2018). Most importantly, I was curious to test if slopes can '*speak'* through these sensors enabling decision makers to listen to not only the progressing slope deformation but also the public concern about slope instability. As highlighted in Chapter 5, I was deeply touched by the frustrated sentiment of an elderly person who I had met during my reconnaissance visit for study area selection: *"Rajale dekhdaina, mato le boldaina"* meaning "The king (authorities) does not see, and the land (that witnesses everything) does not speak."

6.5.2 Mutual agreement of the roles and working procedures

I now describe the interactions with my research participants during the set-up of my monitoring work. At the orientation meeting, we discussed about our roles and the working modality of the research. I reiterated that the monitoring equipment and costs would be arranged by me through my research project funded by GCRF-CDT. I also shared that I would regularly organise meetings to share progress, to answer their queries, to repair the instruments, and to download the data. I restated that if I include their quotes in the research or presentations, I will seek their permission and ensure their anonymity. Similarly, the participants agreed to help in installing the equipment, ensuring safety of the instruments, explaining to family members, peers, and neighbours about the ongoing monitoring work, as well as reporting any complaints or questions immediately to explore solutions. I also reinforced that besides the voluntary engagement in the monitoring work, we could collectively try to explore solutions to other pertinent landslide issues too. It was also important to recognise that our roles would evolve as the research progresses, and that dialogue was important to sort out any confusions or misunderstandings.

As previously noted multiple times, at least 14 households in Mathillo Sigarche temporarily live in nearby public areas during high-risk periods of the monsoon in fear of landslide upslope from their houses. Most people in Mathillo Sigarche and Tallo Sigarche were interested to receive early warnings of the landslides, but I explained that this research was not about generating early warning but was about better understanding the links between rainfall, soil moisture and AEs, which is needed in order to provide warnings in future. This was repeated multiple times to manage expectations. Discussions with my participants and the wider community generally reflected a desire to know if the slopes concerning them are still active and, if yes, how active or risky, they are. Specifically, local people and stakeholders were curious to know how slopes behave in response to different patterns of rainfall, and therefore under what conditions the landslide risk is higher. For example, a landowner who had abandoned the land at Mathillo Sigarche, was interested to know if and when is it okay to recultivate that land, while a parent from Tallo Sigarche was interested to know about the safety status of the school:

"*We all know that landslides might occur after intense rainfall. But I want to know how long I should wait after a storm to go to my house… to check for cattle and do other household works. Right now, we are relying on our intuition*." (Nabin Tamang, Mathillo Sigarche, Male, 27 years, FGD, 2022)

"*Our children go to this school… The location of school is not good. Since my childhood, I remember this area experience small landslides almost every year. In 2020, the ground in front of the main building was washed away. They built concrete retaining walls to stabilize it. However, I think the slope will move again because the slope is fragile.*" (Krishna Basnet, Tallo Sigarche, Male, 45 years, Personal Conversation, 2021)

Recently, there has been push from the local authorities and villagers from the adjoining settlement to change the route of the rural road at Mathillo Sigarche to avoid huge expenditure rebuilding a damaged section of the road. The new proposal was to build a road through abandoned fields, where the landslide monitoring instruments are currently installed. This has further upset the villagers because they believe the fields are unstable. According to local people, this would escalate the problem, and the extended data about slope instability could help to evidence their claims.

During my research, I met the local authorities and DRR practitioners on multiple occasions—both formally and informally. In those meetings, they highlighted the difficulties of understanding complex graphs and datasets. In some meetings, when I showed the analysis drawn from similar research, participants suggested generating simpler graphs and analysis that could be interpreted and used by those with minimal technical background and expertise. This meant sharing simple interpretations of the data on, for example the timing of landslide in the year, periods of excessive rainfall, ensuing soil saturation and slope deformation, with the intention of helping to plan preparedness and anticipatory actions.

Based on these series of discussions with local residents and stakeholders, we mutually considered that the following analysis would be useful:

- What is the rainfall pattern over the year, monsoon, and a week and a day in monsoon?
- How does soil moisture change with respect to rainfall?
- How do the acoustic signals (slope movement) change with respect to rainfall and soil moisture?
    - Which months and weeks experience the highest levels of deformation?
    - What was the corresponding amount of rainfall and soil moisture when there were higher signals of AE?

6.5.3 Monitoring sites selection

The sites for monitoring in the study area were selected in a participatory manner with the involvement of local community members, stakeholders and with inputs from the researchers and practitioners in the field. This involved repeated visits to potential sites and regular communication, sharing of photos and GPS coordinates with my supervisors at Durham University and the potential drilling company through WhatsApp calls and emails. The monitoring sites are located at the coordinates of 27°48'51.39"N, 85°53'20.03"E for Tallo Sigarche and 27°48'51.86"N, 85°53'53.08"E for Mathillo Sigarche. Taking also the insights from Dixon et al. (2022), the sites were selected whilst being mindful of the following criteria:

- Local people having concern about the stability of slope
- Mobile network and good solar radiation availability for power
- Feasibility to transport monitoring equipment including drilling machines necessary to install AE sensor
- Permission from the landowner and community members for installation of instruments
- Monitoring equipment's safety considerations
- Accessibility for installation and maintenance of monitoring equipment
- Water supply accessibility/availability for facilitating drilling work

The monitoring site at Mathillo Sigarche was situated on uncultivated terraces upslope from a sub-settlement (see Figure 6.5). The local inhabitants at Mathillo Sigarche conveyed that the proposed site had experienced landslides multiple times over the past decade. They expressed their heightened concern of increased instability after the 2015 earthquake, which caused the emergence of numerous cracks on the field. Since then, at least 14 households temporarily relocated for periods in monsoon. Residents had curbed their movement through the abandoned terraces, and perceived that the size of cracks had expanded after the owner abandoned cultivation in the field. According to local accounts, the owner completely abandoned farming on the land since 2020 following the occurrence of landslides in adjoining fields.

Figure 6.5: Landslide monitoring site at Mathillo Sigarche on abandoned terraces

The site at Tallo Sigarche was on the slope on which the local primary school is located (see Figure 6.6). The precise locations for the proposed monitoring were tentatively in the middle of each monitored slopes. Both sites were visited by a geologist and researchers from Tribhuvan University, Northumbria University and Durham University, involved in Sajag-Nepal project, to confirm its suitability for slope monitoring.

Figure 6.6: Landslide monitoring instruments installed at Tallo Sigarche (local primary school seen in front of the instruments)

6.6 Instrument installation

6.6.1 Rainfall, soil moisture and temperature monitoring instruments installation

The field monitoring stations were installed at both sites with help from local people. They helped with carrying instruments, digging, and backfilling the installation pit, and installing the frame for data logger and sensor. Steps followed by Pradhan (2021) were considered while installing the rainfall, soil moisture and temperature/humidity sensors and hobo data logger. A 1.4 m pit was dug, and the 10HS soil moisture sensors were carefully inserted horizontally along the undisturbed vertical wall at three depths below the ground surface (0.3m, 0.8m and 1.1m) (see Figure 6.7). After inserting the sensors, the excavated materials were carefully backfilled to achieve the approximate original layering and density. The cables of sensors and solar panel were placed inside a polyvinyl chloride (PVC) pipe to protect them and were then connected to the data logger.

Figure 6.7: Glimpses of soil moisture sensor installation works

A metal frame, as shown in Figure 6.8, was designed and used to mount a solar panel, rain gauge, temperature/relative humidity sensor and data logger.

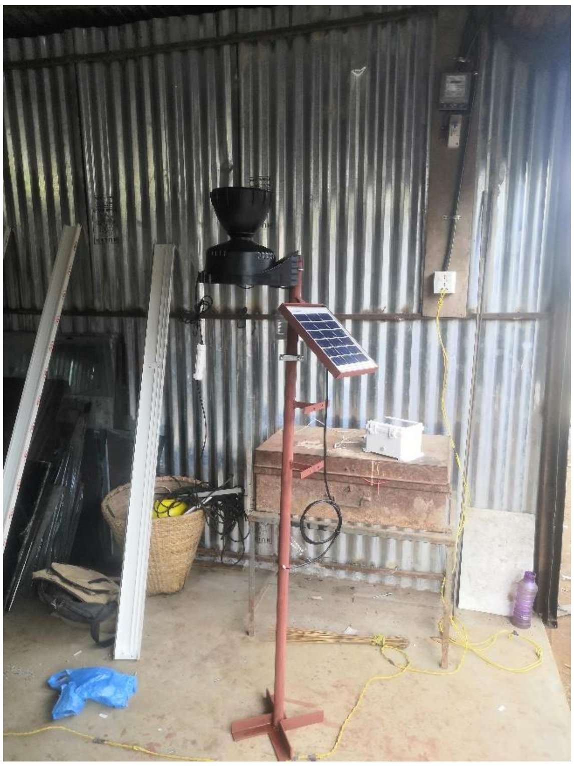


Figure 6.8: Metal frame designed to mount tipping bucket, temperature sensors, hobo logger, and solar panel

The tipping bucket, soil moisture and temperature (relative humidity) sensors were set to post the data to the online Hobolink platform at the intervals of every 5 minutes. On installation day, the demonstration of how the tipping bucket and the Hobo data logger work was done after completing the installation by manually pouring water over the tipping bucket and showing the real time data posted on the Hobolink platform (see Figure 6.9). The installation of rainfall, soil moisture and temperature monitoring devices, was completed in June 2022. The types and specifications of different sensors used have been provided in Appendix 9.

Figure 6.9: Demonstrating how the system works after the installation of weather monitoring instruments

6.6.2 Acoustic emission sensors installation

The AE sensor was installed in two phases. The first phase overlapped with weather and soil moisture sensors installation in June 2022. In this phase, the borehole drilling, and insertion of waveguides (galvanised iron pipes) was completed but the sensors were only available for a second phase in September 2022. To avoid the potential challenges of transporting the drilling machine and wave guide associated with potential monsoon-triggered landslides along the highway and rural roads connecting the study areas, we chose not to wait until the arrival of AE sensors and loggers for drilling to complete the arduous task of drilling before the monsoon reached its peak[39]. We hired a private drilling company to drill ca. 7 m deep boreholes to insert the galvanised iron (GI) pipe to be used as the wave guide for acoustic signals generated during slope deformation. Temporary borehole casings were used during drilling to prevent the borehole from caving in. Unfortunately, the drilling machine broke while at Mathillo Sigarche due to rocky ground. Efforts to resume drilling with local repairs failed and highlighted the need to use a more powerful drill. Drilling recommenced when a 50 m machine became available (see Figure 6.10).

Figure 6.10: Crews from the drilling company administering the drilling process at Mathillo Sigarche

[39] I use the term 'we' here to acknowledge the collaborative planning and decisions made with my research participants

Once the drilling was completed, 38.1 mm GI pipes with c. 3 mm wall thickness were inserted into the boreholes and then the casings were removed. Coarse sand was backfilled inside and around the GI pipe. The GI pipes were installed to a depth of 7 m below the ground surface at Tallo Sigarche and to a depth of 6 m at Mathillo Sigarche with about 0.5 m extended above the ground level for mounting AE sensor. For easy transportation from Kathmandu, pieces of GI pipes with threaded ends and a maximum length of 2.3 m were used. During installation, the pipes were connected using 38.1 mm GI sockets. The lower end of the GI pipe was sealed with a socket having closed conical end at its one side, to ease the pipe insertion and prevent entry of slope materials inside the pipe during insertion (see Figure 6.11).

Figure 6.11: Conical end designed to seal the lower end of GI pipe/wave guide

Locally available clean coarse sand was used to backfill the space within the GI pipe and the annulus around the pipe for amplifying the generation of acoustic emissions upon deformation of the slope and the waveguide. Around 0.2 m of borehole below the ground surface was sealed with bentonite clay to prevent infiltration of surface water to the borehole [see Figure 6.12 (a)]. The top of the steel pipe extended 0.5 m above the collar/ground surface so that the AE sensor could be attached. A piece of GI pipe (c. 0.5 m) was also installed adjacent to the waveguide to mount the GAA data logger that was installed in the second phase of AE sensor installation that took place in September 2022. This set-up was covered with half an oil drum to protect the sensor and data logger—installed in second phase—against rainfall and animals.

Figure 6.12: (a) Sealing the surface with bentonite, (b) AE sensor and its different parts, and (c) data logger

In second phase of AE sensor installation, the AE sensor was attached using silicone and hose clamps at approximately 0.25 m from the collar of waveguide, and the GAA data logger was mounted to the adjacent metallic frame. The acoustic emission sampling intervals were set to every 15 minutes – this is the period over which emission counts, or ring down counts, would be totalled and logged. GAA Reference Manual (RST Instruments, 2019) was followed while installing GAA sensor and data logger on the waveguide. While installing, a demonstration of how the sensor works was done amongst the participating villagers by striking the top of the wave guide (GI pipe) with something to artificially generate the acoustic signals and showing the generated signal data on the laptop (Dixon et al., 2022). This was done to show how the scientific instruments, such as this, may help listen to the slope movement.

The community engagement in both phases of installing acoustic emission sensor was encouraging. People helped in transporting the remarkably heavy drilling equipment and GI pipes from road heads to the site—one of the engines being as heavy as 80 kgs, but also helped by providing suggestions on potential drilling points. They also helped in making temporary trails to the sites for transporting drilling equipment, arranging continuous water supply required for cooling the drilling machine, connecting GI pipes (see Figure 6.13) and inserting into the boreholes, and backfilling inside and around the waveguides. Local people also contributed by helping to install a fence around the equipment to protect it from physical damage. The largely voluntary help was possible due to the individual connection and mutual trust established with the community members through the ethnographic engagement. Besides local people's support and involvement, the technical skills and voluntary contribution of *Babu daai*[40]—the driver of my hired vehicle, was instrumental during installation of both weather as well as AE monitoring instruments and repairing them as required. The AE sensors installation completed, and data collection began in September 2022. The AE data was downloaded from the AE data logger manually during later site visits.

Figure 6.13: Birkha Shrestha, a local inhabitant of Tallo Sigarche, helping with smoothening the sockets connecting pieces of GI pipes to be used as wave guide for acoustic emission sensor

[40] *Daai* is a Nepali term denoting respect to a male who is older (not necessarily related to by blood).

6.7 Data download and quality control

The rainfall, soil moisture, relative humidity and temperature data collected by the Hobo sensors were automatically posted online. While the weather data could be accessed and downloaded remotely using the online Hobolink platform, the AE data were downloaded manually during site visits (see Figure 6.14).

Figure 6.14: Downloading of AE data

Anticipated errors in the data such as artificially generated AE and rainfall data during community engagement activities, or servicing and download, and unusual values of weather parameters such as exceptionally or impossibly high rainfall values (for example more than 200 mm rainfall in an hour), negative or continuously stable soil moisture values were removed before analysing the data. In this study, soil moisture data was collected as volumetric water content (VWC), representing the ratio of the volume of water to the unit volume of soil (Toková et al., 2019). Additionally, when necessary and feasible, such as for cross-checking doubtful instrumental data, or addressing data gaps observed in instrumental data for some technical reasons, I collaborated with local people to gather firsthand insights about the weather patterns and local environmental conditions during the concerned period.

Whilst the instruments monitoring the weather were installed by the second week of June 2022, we encountered a repeating problem with mobile communication network. We tried replacing the Nepali sim card with Machine-to-Machine (M2M) sims supplied from UK. We also increased the voltage supply using a new solar panel, an external battery and charge controller available locally. None of these attempts improved the data loss and so a decision to replace the data loggers with new ones was taken. Therefore, data collection began only after the replacement of old data loggers[41] with the new ones including the new batteries in the second week of September 2022. This meant that we missed out the weather data of approximately three crucial monsoon months in 2022. Even when we replaced the old logger with a new one, there were lots of missing data, for periods up to 31 days during December 2022 to January 2023 perhaps linked to network issues at the site, and errors (such as negative values of VWC) in weather parameters for Tallo Sigarche until 14th April 2023. Inclusion of periods with very high data loss might result in non-representative outcomes for the site. Hence, to avoid this, the VWC analysis for Tallo Sigarche has been undertaken for the period after 14th April 2023 only, when the data are more regular.

Nonetheless, the precipitation data for Tallo Sigarche have been analysed quoting the missing period in the analysis. According to local residents, and as also indicated by the precipitation data from Mathillo Sigarche, the periods with gaps fell mostly during the dry months when the sites experienced negligible rainfall. Hence, it can be assumed that the data gaps had minimal impact on the daily, monthly, seasonal, and cumulative rainfall at Tallo Sigarche. The tipping bucket (rainfall monitoring sensor) at Mathillo Sigarche also encountered some issues from 8th of September 2023. Hence, the weather data beyond the period of 8th September 2023 have not been included in the analysis for Mathillo Sigarche. The issue on tipping bucket was sorted out during field visit to sites in March 2024 for final sharing meetings.

6.8 Community engagement strategy

My engagement with the wider community at my study sites also evolved through time. During fieldwork, I regularly communicated research activities, plans and progress to the

[41] The weather monitoring instruments used by a former PhD Student (see Pradhan, 2021) at nearby Bhotekoshi RM was used at the beginning at my sites.

community members through informal conversations, semi-structure interviews and focus group discussions. Even when physically absent in field due to COVID-19 pandemic related restrictions, I maintained consistent contact with key people in the communities actively involved in the installation of the monitoring instruments. I used virtual means such as phone calls or Facebook Messenger calls and text message exchanges. During these conversations, I not only updated them of the research progress and plans but also requested them to spread the research objectives, activities, plans and current findings among their families, neighbours, and the broader community.

During a planning meeting conducted in field for installation of landslide monitoring instruments when I was using my laptop to present a sketch showing the overview of the landslide monitoring equipment, a participant suggested to print the sketch in flex print in larger size such that it is easier to visualize and discuss. I wholeheartedly embraced his suggestion during my subsequent visit to the community (see Figure 6.15).

I returned to the UK in October 2022 to focus on data analysis and writing after completing my fieldwork. While I was in the UK, I maintained regular ‘small talk’ (Driessen & Jansen, 2013) or text exchanges with my research participants who had WhatsApp, Facebook messenger or Viber accounts. These ‘small talk’ exchanges—particularly during the periods of quiescence—helped me remain connected with community members and largely expedited the follow-up virtual conversations to triangulate and share information when my presence in field was not possible. I made a short visit to my sites in June 2023 to share my preliminary findings. Unfortunately, I could not meet as many people as expected because of the short duration of visit, and a need to spend some time maintaining the equipment that had encountered some technical issues. Furthermore, the visit overlapped with period when many participants were busy preparing fields for millet and paddy plantation. In the meetings I did hold, we discussed potential ways to reach others, and the idea to record a video of a PowerPoint presentation with my voice to be shared via Facebook messenger with local residents emerged. To overcome issues with file sizes, I uploaded the video to YouTube (Shrestha, 2023) and shared the link via Facebook messenger, WhatsApp, and Viber. This turned out to be a happy evolution of strategy and was quite encouraging as the video was watched more than 100 times within 15 days of upload. By December 2023, the video was viewed more than 200 times. This has of course motivated me to upload other relevant videos to YouTube in future.

Meanwhile, I travelled to study areas in March 2024 to present my final research findings, and to concurrently assess the congruence and differences between the instrumental data and people's observations regarding rainfall, soil moisture and slope instability conditions. Details on this are provided in the subsequent chapter.

Figure 6.15: Discussion with school management committee representatives and teachers at Tallo Sigarche about landslide monitoring parameters and instruments

6.9 Chapter summary

In this chapter, I delineated the contextual backdrop and participatory process that informed the planning and installation of the landslide monitoring instruments at two sites in the study area. The process involved a series of one-to-one and group meetings, both in-person and virtual, to discuss and negotiate the research objectives, monitoring sites and parameters, and roles of the researcher (myself) and local collaborators. The next chapter will share the findings from the data analysis of monitored parameters. Additionally, it will also elaborate on the overall accomplishments, challenges encountered, and future trajectories for addressing the knowledge gaps expounded upon in Section 6.3 of this chapter.

Chapter 7 "Can slopes speak?" Insights from the participatory landslide monitoring in Nepal's Sindhupalchok District

7.1 Overview

In the previous chapter, I outlined the background and processes employed in co-designing and installing the landslide monitoring instruments. I also identified key knowledge gaps the participatory landslide monitoring component of my research aims to address. Here I will present the analysis of monitoring data, such as the patterns observed in rainfall, soil moisture, and acoustic emissions and the relationship between them. I will reflect on the outcomes of participatory landslide monitoring with particular emphasis on the potential contribution towards filling knowledge gaps, as detailed in Section 6.3 of Chapter 6.

In this research, rainfall and soil moisture were monitored because both intense short duration rainfall and longer term more moderate rainfall can saturate the soil, as reflected in the soil moisture level, measured here as volumetric water content (VWC), consequently increasing the potential for landslides (Guo et al., 2023). Additionally, subsurface acoustic emissions were monitored because these data indicate very fine levels of slope deformation (Smith et al., 2017). While rainfall and soil moisture parameters represent the broad stress conditions for landslides and have been used previously in various contexts and regions of Nepal (see, for example, Paul et al., 2020; Thapa et al., 2023), the incorporation of AE data in landslide monitoring, a more direct measure of deformation, is a novel endeavour in Nepal.

A year-long record of rainfall, soil moisture and AE data has been analysed. The analysis aimed to assess the long-term mean, monsoonal, weekly, daily, and sub-daily changes, and the interrelation between these parameters over these timescales. Despite the nature of the data relative to the focus of my research, I have made a concerted effort throughout to articulate the processes, findings, discussions, and conclusions in a manner accessible and useful for non-technical audiences, including community members and other local stakeholders.

The data analysis has revealed distinct seasonal trends in rainfall, and the resultant soil moisture and AEs, with relatively higher values in the summer monsoon, signalling a higher risks of slope instability in monsoon. This underscores the important role of rainfall in augmenting soil moisture levels and subsequent slope deformation. The findings serve as a cautionary reminder of the importance of limiting (un)planned development, such as road construction, during the monsoon months in landslide-prone regions. While the analysis of AE data presented here does not indicate an immediate cause for concern regarding slope instability, elevated values observed during the monsoon underscore the notable seasonal variability, and the need for vigilance and precautionary measures during the monsoon. This chapter also delves into the benefits offered by the participatory landslide monitoring in addressing knowledge gaps, described in Chapter 6. Here I also offer suggestions and considerations for future work in continuing, scaling-up or replicating the landslide monitoring approach elsewhere.

This chapter is structured as follows. Section 7.1 provides an overview of the study. Section 7.2 delves into the patterns in rainfall, volumetric water content and AE data observed during the monitoring period. Likewise, Section 7.3 provides a discussion and Section 7.4 draws conclusions from this component of my research.

7.2 Landslide monitoring results

7.2.1 Rainfall patterns

The period considered for rainfall analysis extends from 13 September 2022 to 8 September 2023 for Mathillo Sigarche, and 13 September 2022 to 5 October 2023 for Tallo Sigarche. During the monitoring period, Mathillo Sigarche recorded a total rainfall of 2848 mm, while Tallo Sigarche recorded 2561 mm. However, as illustrated in Figure 7.1 (b), Tallo Sigarche had a data gap of 49 days due to technical issues such as the communication network issues and sensor failure, which were subsequently rectified. The major technical issues faced by slope monitoring instruments and the strategies followed to deal with them had been presented in Section 6.7 of Chapter 6.

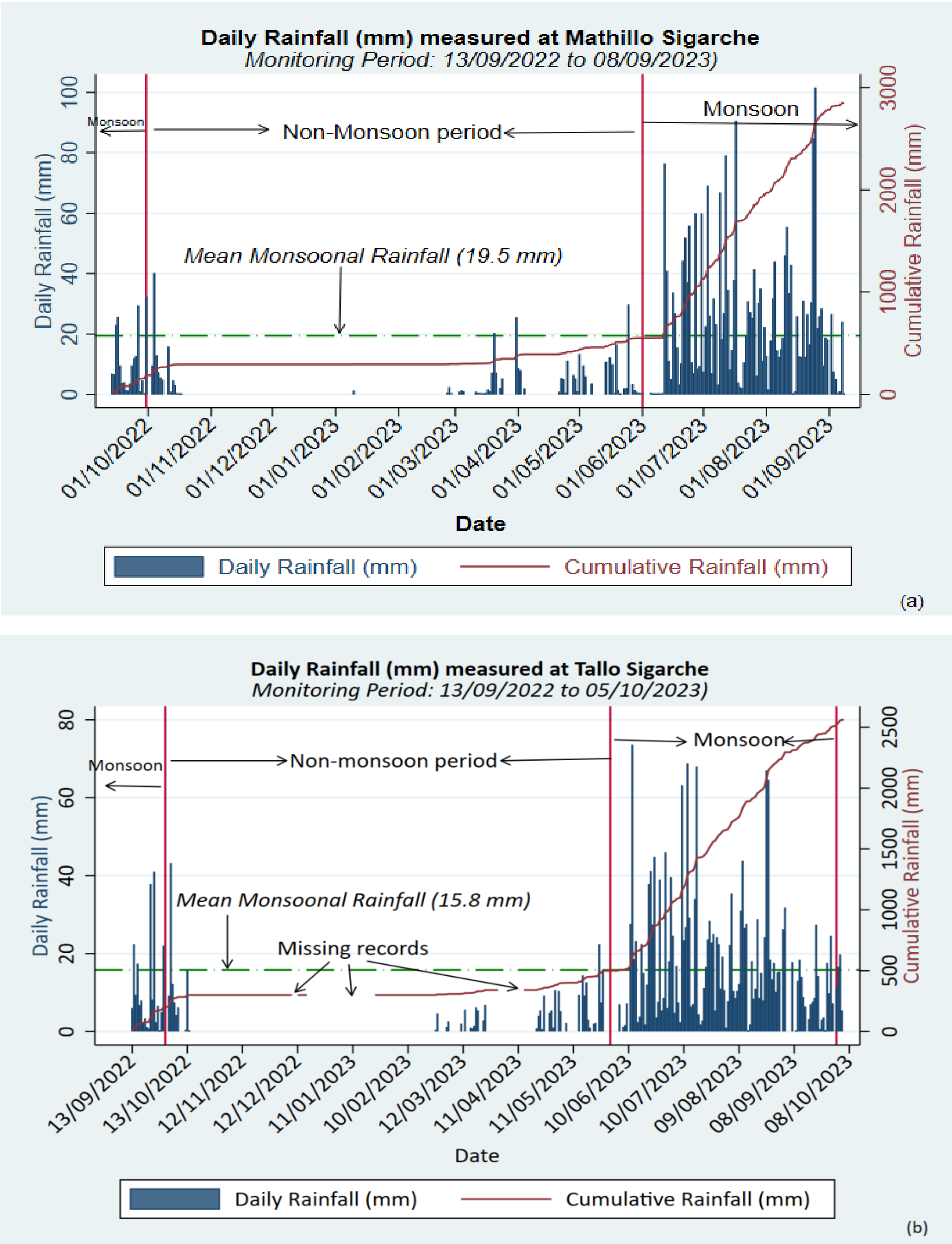


Figure 7.1: Daily Rainfall patterns observed at (a) Mathillo Sigarche and (b) Tallo Sigarche

As expected, more than 85% of the rainfall was recorded during the monsoon[42] at both monitoring sites. A total of 146 out of 361 observation days at Mathillo Sigarche, and 213 out

[42] For ease and uniformity in analysis, June-September is considered as monsoonal months.

of 339 observation days at Tallo Sigarche experienced daily rainfall of at least 1 mm. Of these, ~70% of wet days at Mathillo Sigarche and over 55% at Tallo Sigarche occurred during the monsoon[43], indicating the highest proportion of wet days during the monsoon seasons.

Throughout the monitoring, the Department of Hydrology and Meteorology (DHM)'s 24-hour precipitation threshold for elevated flood and landslide risk, that is set at 140 mm, was not surpassed. The mean daily rainfall during the monsoon was ~19.5 mm and ~15.8 mm at Mathillo Sigarche and Tallo Sigarche respectively. As can be seen in Figure 7.1, both sites experienced many days in the monsoon with rainfall totals less than the mean monsoonal daily rainfall. Likewise, both sites experienced days outside of the monsoon when the rainfall exceeded the mean daily monsoon rainfall. Further information on the daily rainfall is summarized in Table 7.1:

Table 7.1: Summary of the daily patterns observed at Mathillo Sigarche and Tallo Sigarche

	Monsoon (June-September)		**Non-monsoon (October-May)**		**Overall observation period**	
Parameters	**Mathillo Sigarche**	**Tallo Sigarche**	**Mathillo Sigarche**	**Tallo Sigarche**	**Mathillo Sigarche**	**Tallo Sigarche**
Observation days	118	140	243	199*	361	339*
Total Rainfall (mm)	2588	2209.6	260.2	351.8	2848.2	2561.4
Mean Rainfall (mm)	19.5	15.8	1.5	1.8	7.9	7.5
Maximum Daily Rainfall (mm)	101.6	73.6	40.2	43.2	101.6	73.6
Rainy days (when rainfall >=1 mm)	102	121	44	92	146	213
Days when rainfall <1mm	16	19	199	107	215	126
Mean Rainfall during rainy days (mm)	23.3	18.2	7.2	8.1	19.4	15.6

Note: Monitoring periods considered for this research are from 13/09/2022 to 08/09/2023 for Mathillo Sigarche and 13/09/2022 to 05/10/2023 for Tallo Sigarche and asterisk (*) denotes the database excludes 49 days of missing records.

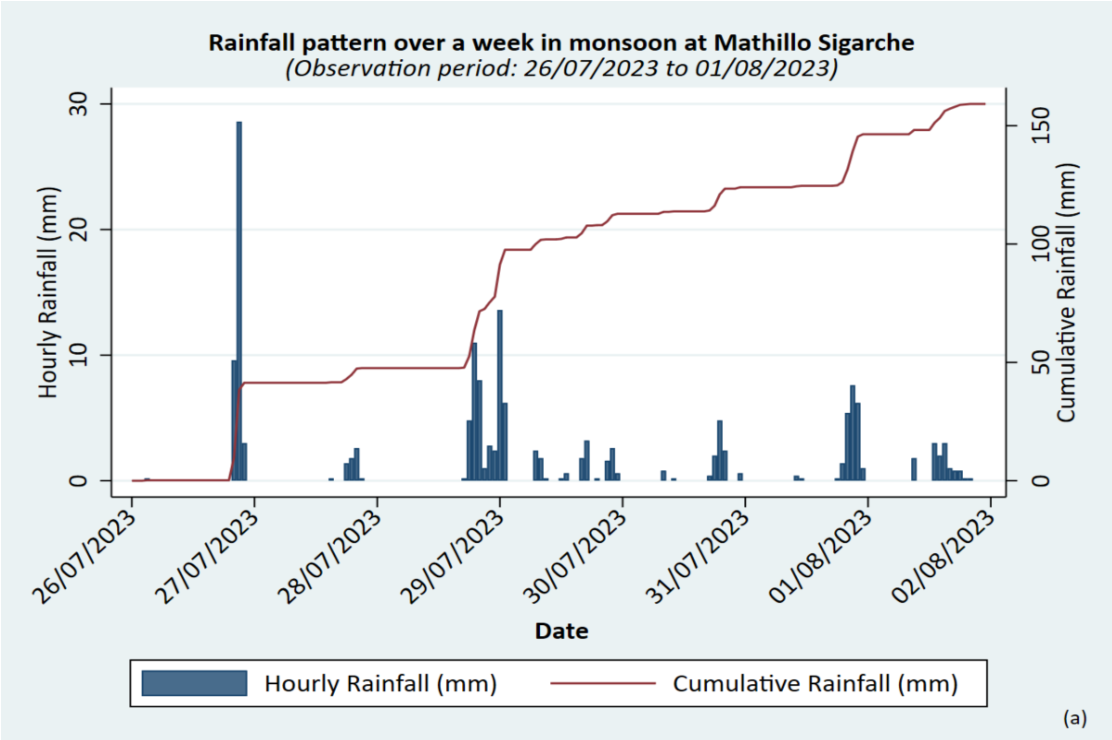
The rainfall pattern during a representative week and a day in monsoon are presented in Figures 7.2 and 7.3. For weekly patterns, the hourly rainfall data between 26th July and 1st August 2023 was chosen as this period is when the monsoon is generally or close to its peak. Similarly, precipitation on 29th July 2023 was used to consider sub-daily variability within a

[43] During the monitored period, there were 102 wet days (days with rainfall >=1mm) observed at Mathillo Sigarche while Tallo Sigarche recorded 121 wet days during monsoon. However, it is important to note that the monitored periods are different for these sites.

monsoonal day[44] (see Figure 7.3). It is worth noting from the data analysis that not every day within the monsoon has similar or higher amounts of rainfall. Precipitation tends to be concentrated over a certain period within a week or a day, with intervals of no or low rainfall in between. For instance, only four days (26th, 28th, 29th and 31st July) in the representative week considered for analysis witnessed rainfall totals higher than the mean daily monsoonal rainfall[45], amounting to ~19.5 mm for Mathillo Sigarche and ~16.5 mm for Tallo Sigarche (see Figure 7.2). Through the monitoring period, 16 monsoon days at Mathillo Sigarche and 19 at Tallo Sigarche did not receive any rainfall (see Table 7.1).

[44] 5 minutes interval precipitation was used in our analysis.

[45] Mean monsoonal rainfall for Mathillo Sigarche is ~19.5 mm and for Tallo Sigarche is ~16.5 mm.



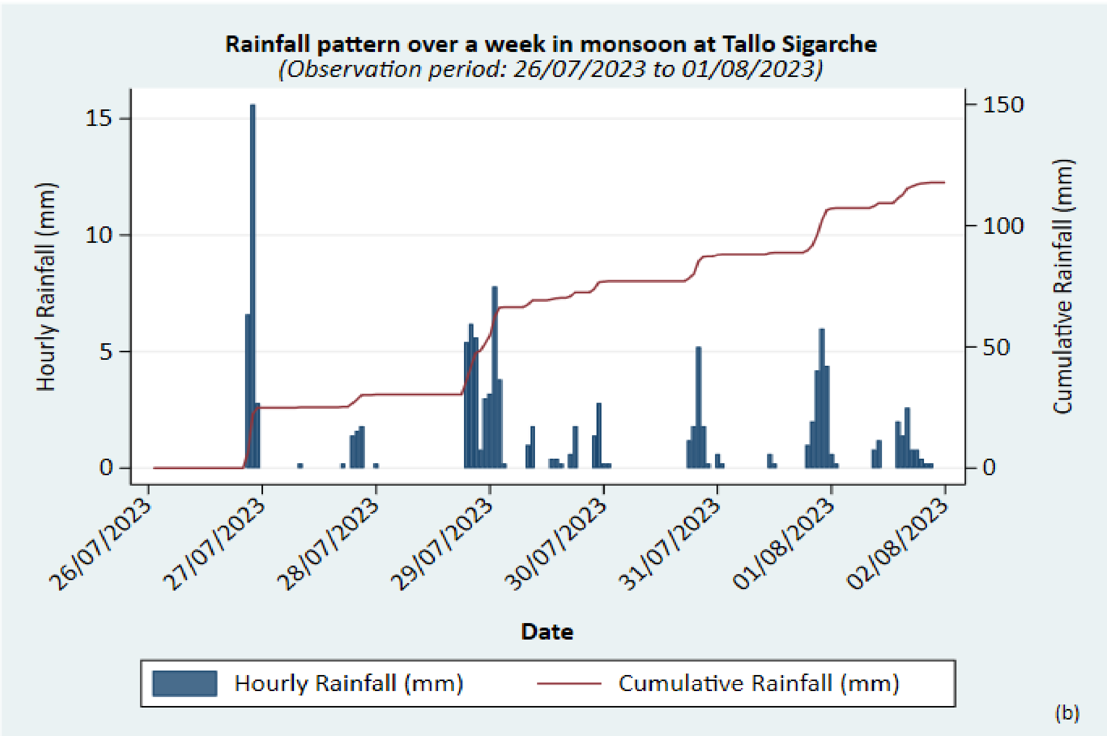


Figure 7.2: Rainfall pattern over a week in monsoon at (a) Mathillo Sigarche and (b) Tallo Sigarche

Similarly, on 29th July, Mathillo Sigarche and Tallo Sigarche received rainfall of ca. 35 mm and 22 mm respectively, but as can be seen in Figure 7.3, rainfall is not evenly distributed through the day. Rainfall is rather concentrated, with more than half of precipitation occurring in the hours immediately following midnight. Within the 24-hour period, there were at least 10 hours without rainfall. Likewise, throughout all monitoring periods, the precipitation did not surpass DHM's threshold for hourly, three hourly, six hourly, twelve hourly and twenty-four hourly accumulations[46].

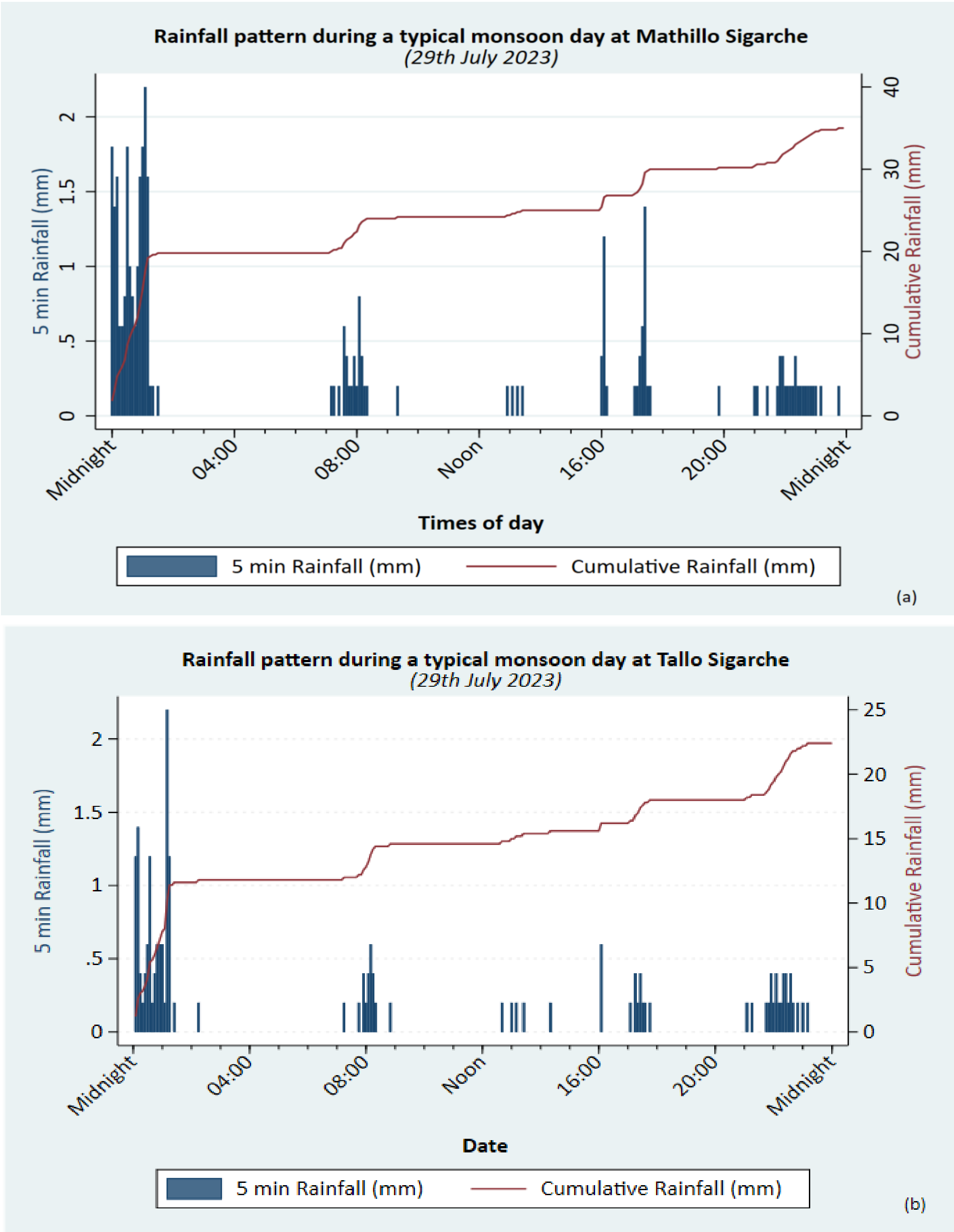


Figure 7.3: Rainfall pattern during a typical day in Monsoon at (a) Mathillo Sigarche and (b) Tallo Sigarche

46 Department of Hydrology and Meteorology's website mentions rainfall amount of 60 mm in 1 hr, 80 mm in 3 hr, 100 mm in 6 hr, 120 mm in 12 hr and 140 mm in 24 hr as the warning level indicating the potential threat for landslides in steep slope. See https://hydrology.gov.np/#/rainfall_watch?_k=78fus2 for the warning levels for rainfall. These intensities are widely promoted as being warning levels for landslides by many NGOs working in disaster risk reduction sector in Nepal.

Figures 7.2 and 7.3 further highlight that although rainfall patterns are similar at the two sites the rainfall totals differed. Mathillo Sigarche observed relatively higher rainfall compared to Tallo Sigarche, highlighting that rainfall can vary even over short distances and changes in elevation (Lempert et al., 2023; Talchabhadel et al., 2021). This also suggests the possibility of false or missed alarms in early warning systems based on only rainfall data given the small-scale variability in precipitation.

To further evaluate the distribution of monsoon rainfall during a day, the mean hourly precipitation during 2023's monsoon was computed for both sites [see Figure 7.4 (a) and (b)]. Most rainfall occurred in the afternoon through to midnight, with the highest average hourly rainfall occurring at 7pm for both sites. This suggests the higher probabilities of encountering rainfall in the monsoon season between the afternoon and midnight. However, one should not rule out the possibility of heavy precipitation at other times, as each monsoon day can be different. Figure 7.3 (a and b) underscores the need for caution when utilizing the hourly average precipitation data [Figure 7.4 (a) and (b)], as it shows the precipitation distribution with highest proportion of the rainfall occurring during the first 1.5 hours after midnight.

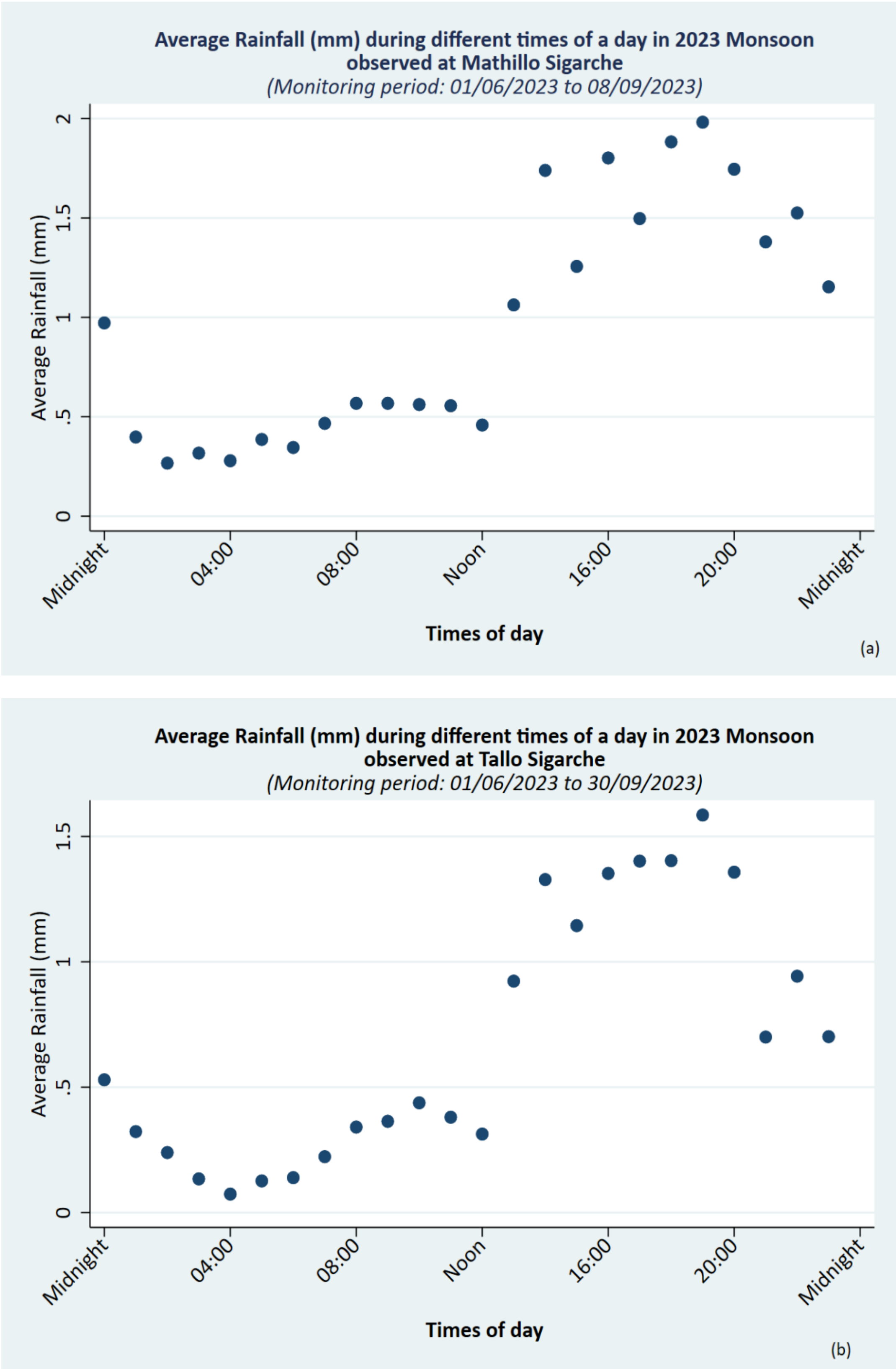
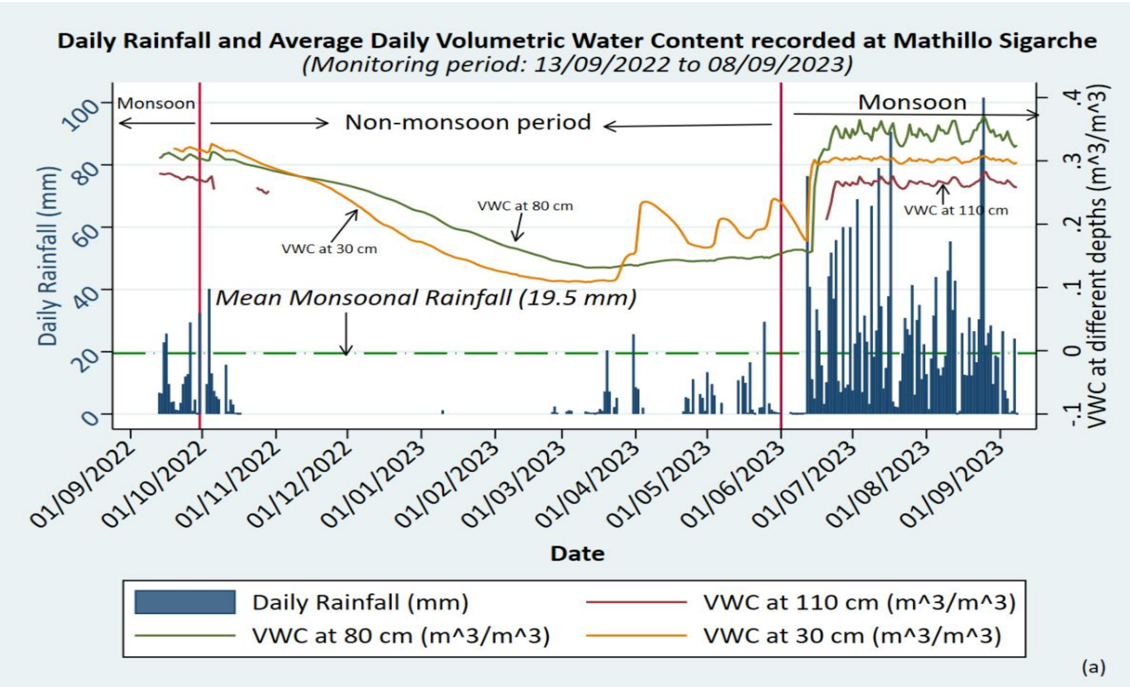


Figure 7.4: Hourly Average Rainfall (mm) during 2023's Monsoon observed at (a) Mathillo Sigarche and (b) Tallo Sigarche

7.2.2 Changes in soil moisture

The temporal patterns of the average daily soil moisture, represented in volumetric water content (VWC), at three depths below the surface—30 cm, 80 cm, and 110 cm—at Mathillo Sigarche and Tallo Sigarche during the monitoring period are shown in Figure 7.5. As expected, the VWC follows a seasonal pattern with higher values representing a greater degree of saturation during the monsoon season.



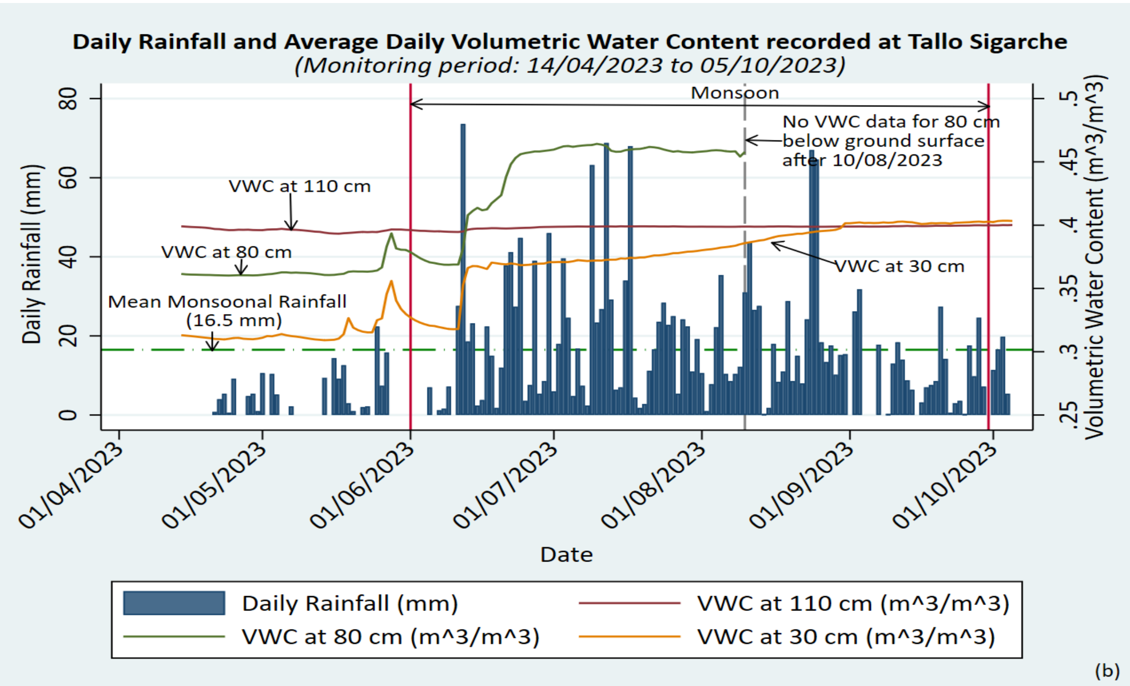


Figure 7.5: Daily Rainfall and daily average VWC at different depths at (a) Mathillo Sigarche and (b) Tallo Sigarche

As illustrated in Figure 7.5, the VWC data from Tallo Sigarche before 14th April 2023 have been excluded from analysis due to data gaps. Additionally, the figure also shows gaps in VWC data at 110 cm at Mathillo Sigarche from the second week of October 2022 to the third week of June 2023, and at a depth of 80 cm in Tallo Sigarche from the second week of August 2023. These readings are associated with sensor failures. The sensor at Mathillo Sigarche was replaced during field visit for sharing of preliminary findings conducted in June 2023, whereas the sensor at Tallo Sigarche was replaced in March 2024 during my visit to the sites for final research sharing.

After the withdrawal of the 2022 monsoon in mid-October, the VWC fell gradually and continuously [see Figure 7.5 (a)]. Winter (November-February) received very low amounts of rainfall: <5 mm of rainfall was recorded at Mathillo Sigarche during this period. This is only ~4% of average winter rainfall recorded over the period from 1990 to 2022[47] based on data from the nearest meteorological station at Gumthang (refer to Figure 7.6). The low levels of rainfall resulted in the failure of winter crops, causing significant challenges for the residents of Mathillo Sigarche, exacerbating their ongoing struggles with food insecurity. Consequently, this situation further compounded the impacts of the wider set of challenges faced by the community. The following quote from a local resident exemplifies the seriousness of this winter drought on crops:

"We could not harvest anything from the wheat plants this year. The plants failed to mature due to lack of rainfall. We fed the immature wheat plants to cattle." (Ujeli Tamang, Mathillo Sigarche, Female, 54 years, Personal Conversation, 2023)

The occurrence of precipitation in March 2023[48] ended four months of dry weather but also triggered fluctuations in VWC at different depths (see Figure 7.5). At Mathillo Sigarche, VWC at 30 cm was quick to respond compared to the sensor at 80 cm depth during the pre-monsoon (March-May/Mid-June) and remained high throughout the pre-monsoon. Once the monsoon began, the VWC at 80 cm started rising and soon surpassed the VWC values at 30 cm. Throughout the monsoon, the VWC at 80 cm remained high level but showed a high

[47] Average rainfall observed at Gumthang for November-February is 118.3 mm based on data of 1990-2022.

[48] March through May/mid-June is considered pre-monsoon season in Nepal.

degree of variability compared to the VWC at all other depths. Lower magnitude fluctuations of VWC at 30 cm at Mathillo Sigarche could be because of the effect of regular rainfall, leading to limited changes compared to pre-monsoon periods. This may also be due to the probable alterations in the compactness of soil layers while replacing the broken sensor at 110 cm depth executed on 16th June 2023. While due attention had been given to maintain the original soil profile, with the sensors inserted in the undisturbed walls of the pit, the chances of some alterations in porosity cannot be ruled out. Similarly, higher fluctuations at 80 cm during the monsoon could possibly be due to the cumulative effect of rainfall and seepage associated with cracks in the terraces creating preferential flow paths (Pradhan, 2021).

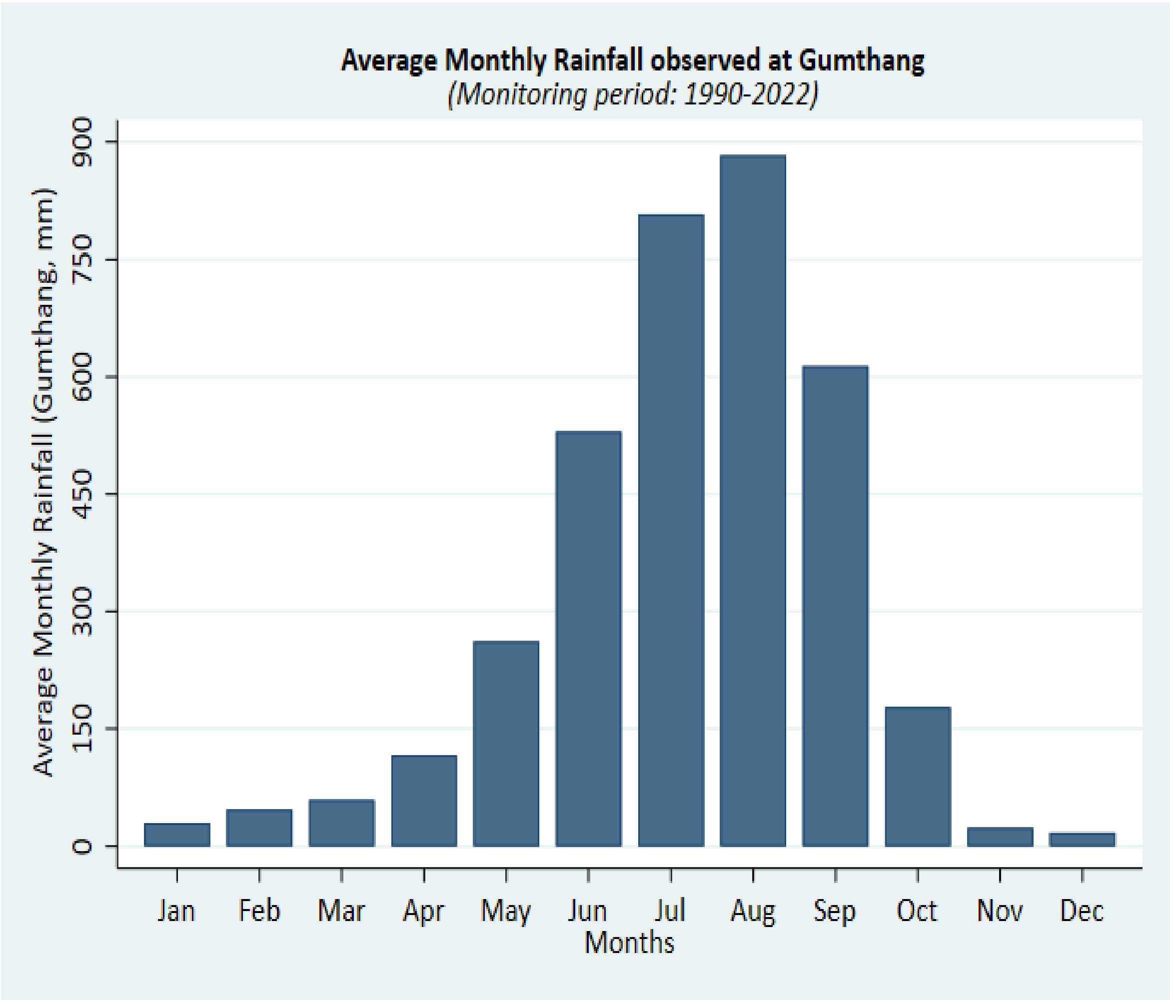
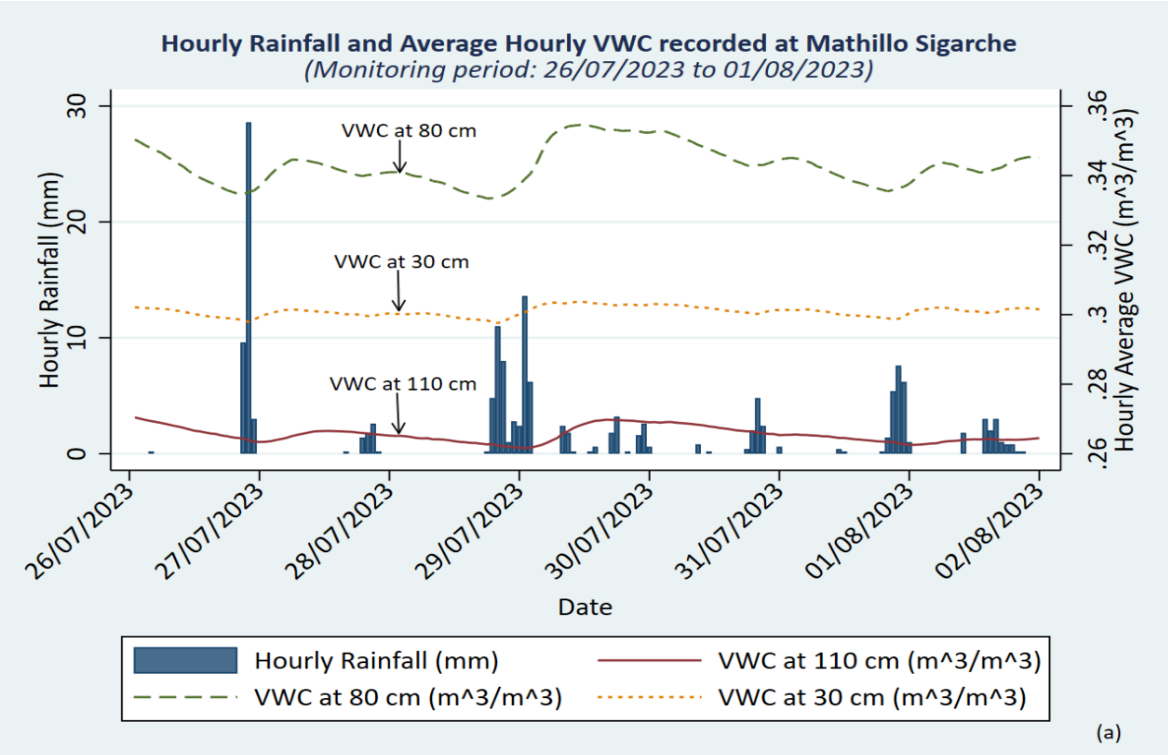


Figure 7.6: Monthly Average Precipitation observed at Gumthang over 1990-2022 (Data Source: DHM[49])

[49] Department of Hydrology and Meteorology (DHM)'s precipitation data was purchased and used for analysis of monthly average precipitation observed ag Gumthang.

At Tallo Sigarche, the analysis of available data shows very little variation in average VWC at 110 cm throughout the monitoring period. This could mean the VWC at Tallo Sigarche is less influenced by precipitation and infiltration, but rather related to the overall wet nature of the slope, irrespective of seasonal changes. Local inhabitants recalled the presence of seasonal springs, which were buried for construction of the school building. The possibility of the water table being high, with soil at 110 cm being close to saturation, can be assumed by observing numerous points of seepage during the monsoon. A further analysis of the in-situ soil properties would be necessary to validate this. Additionally, the VWC at depths of 30 and 80 cm at Tallo Sigarche did not fluctuate significantly during the monsoon, indicating the overall wet nature of the site with a limited role of drying and wetting processes (Pradhan, 2021).

To evaluate how soil moisture changes at a smaller temporal scale during monsoon, the changes in hourly VWC at both monitored sites in response to hourly rainfall occurrences for a mid-monsoon week have been analysed. As with the analysis of rainfall patterns above (Section 7.2.1), the period between 26th July 2023 to 1st August 2023 was chosen [Figure 7.7 (a) and (b)]. Figure 7.7 (b) shows that VWC at all three depths at Tallo Sigarche had minimal fluctuation, indicating near saturation of the soil. However, at Mathillo Sigarche, some variability in the hourly VWC was observed in response to rainfall events and infiltration [see Figure 7.7 (a)]. Furthermore, Figure 7.7 (a) highlights that VWC at 80 cm depth fluctuates more than VWC at depths of 110 cm and 30 cm at Mathillo Sigarche.



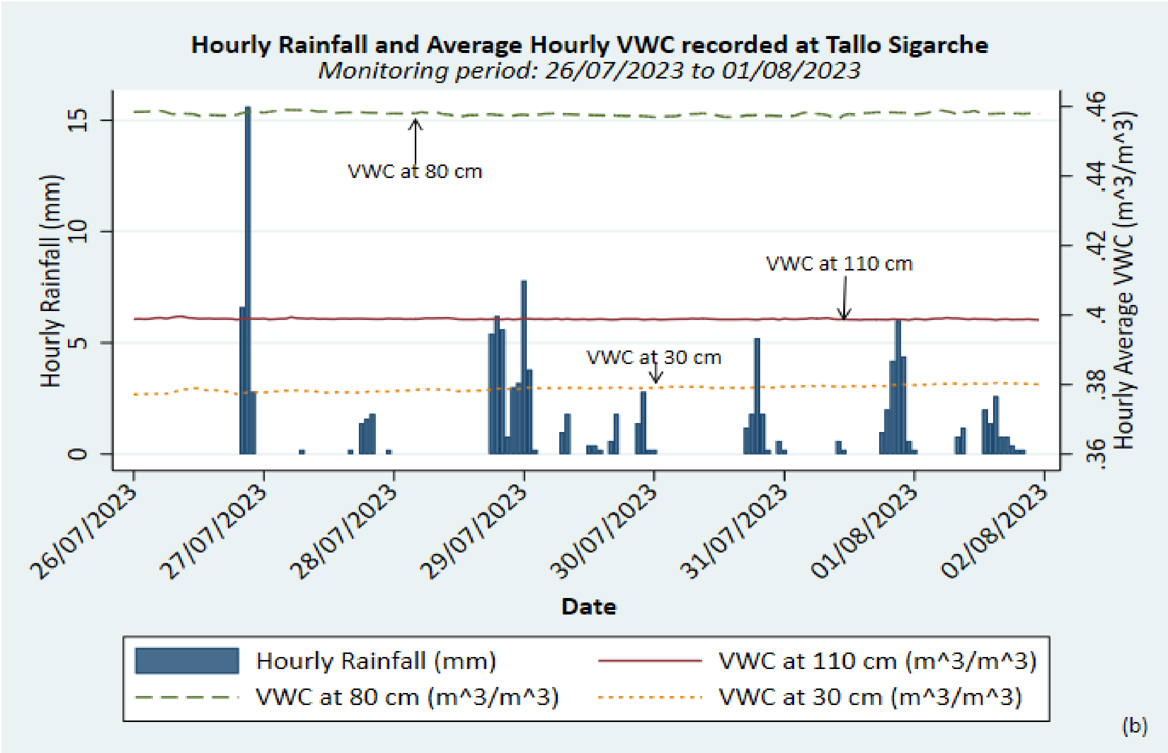


Figure 7.7: Patterns of Hourly Rainfall and Average Hourly VWC recorded at (a) Mathillo Sigarche and (b) Tallo Sigarche

A closer look at the onset of rainfall on 28th and 29th July in Mathillo Sigarche shows that the VWC at 80 cm and 30 cm responded almost instantly (within 3-4 hours of rainfall initiation) whereas the response in VWC at 110 cm depth was lagged by about 8-9 hours (see Figure 7.8). Figure 7.8 highlights that VWC at 80 cm and 110 cm continues to increase for additional hours

(~4-5 hours for VWC at 80 cm and ~8-9 hours for VWC at 110 cm) even after the VWC at 30 cm starts stabilizing or declining, in response to the cessation of rainfall. This exemplifies the role of rainfall and infiltration on the timing of VWC fluctuations at depth and emphasizes the potential for a delayed landslide response even after rainfall has stopped.

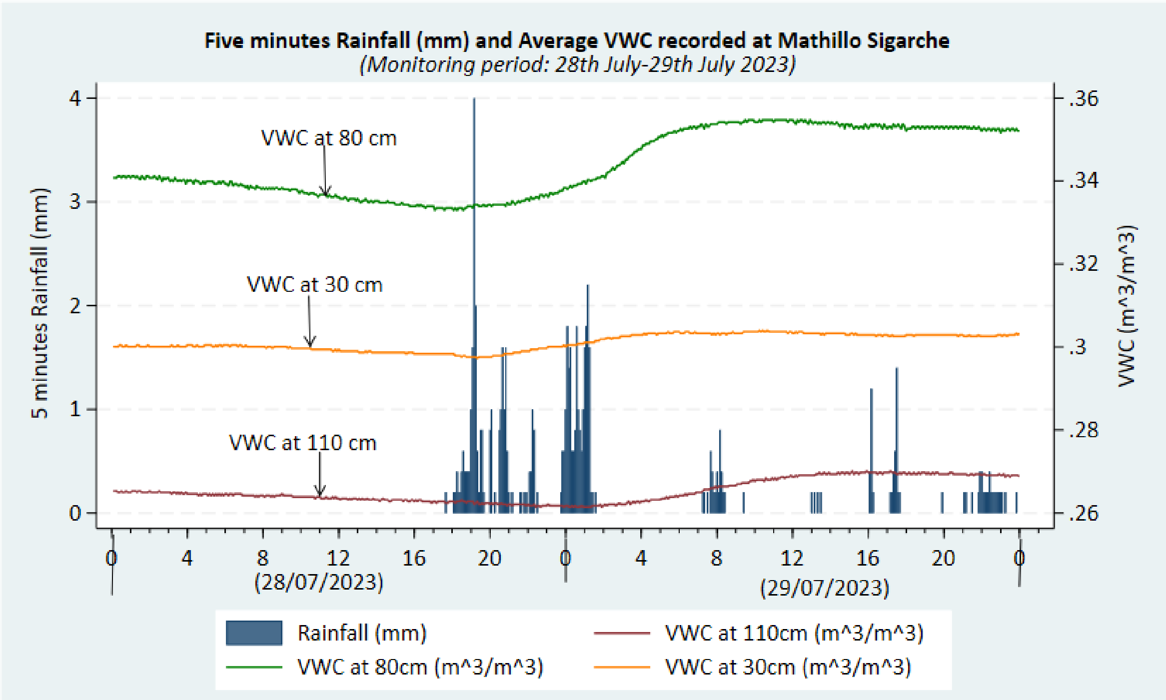


Figure 7.8: Five minutes Rainfall and Average VWC recorded at Mathillo Sigarche during 28-29th July 2023

To further explore the relationship between precipitation and VWC response over the 2023 monsoon, a cross-correlation function (CCF) has been applied to analyse the lag-time between hourly precipitation and VWC fluctuations at different depths (Mahmood et al., 2012; Pradhan, 2021). Quantifying time-lag between rainfall and VWC could be helpful for better understanding the duration over which people should maintain a heightened degree of caution against landslide risk, even after the rainfall ceases.

The CCF was obtained by dividing the covariance of the hourly rainfall and average hourly VWC by the product of their standard deviations, as shown in following equation:

$$CCF = \frac{\sum_{T=1}^{N-K}(x_T - \bar{x})\,(y_{T+K} - \bar{y})}{S_x S_y} \qquad [7.1]$$

Where,

N = number of observations

T = row number

K = lag

$\bar{x}$ = mean of x

$\bar{y}$ = mean of y

S_x = Standard Deviation of hourly rainfall = $\sqrt{\sum_{T=1}^{N}(x_T - \bar{x})^2}$

S_y = Standard deviation of average hourly volumetric water content = $\sqrt{\sum_{T=1}^{N}(y_T - \bar{y})^2}$

The correlation between rainfall and the VWC time series was considered significant if the following condition was observed:

$$CCF > \frac{2}{\sqrt{N-|K|}} \qquad [7.2]$$

Figure 7.9 (a-f) outlines the CCF between hourly rainfall and average hourly VWC at 30 cm, 80 cm, and 110 cm for the 2023 monsoon. As shown in Figure 7.9 (a-c), the strongest correlation between rainfall and VWC at 30 cm, 80 cm, and 110 cm depths at Mathillo Sigarche was obtained at lag times of 9 hours (8 to 12 hours), 8 hours (7 to 10 hours) and 13 hours (11 to 15 hours), respectively, with significant correlations.

Likewise, at Tallo Sigarche, as shown in Figure 7.9 (d-f), the strongest corelation between rainfall and VWC at 30 cm, 80 cm and 110 cm was observed at lag times of 9 hours (7 to 10 hours), 4 hours[50]* (2 to 5 hours) and 13 hours (12 to 14 hours), respectively. While the corelation between rainfall and VWC at 80 cm and 110 cm with corresponding time lags were significant, that between rainfall and VWC at 30 cm (lag of 9 hours, 7 to 10 hours) was not significant.

As a result of the VWC sensor malfunctioning, the analysis between rainfall and VWC at 80 cm depth at Tallo Sigarche was conducted only for the period between 1st June and 10th August 2023. Similarly, the analysis between rainfall and VWC at 30 cm and 80 cm depths for Mathillo Sigarche was undertaken for the period between 1st June to 8th September because of the failure of the rain gauge after 8th September. Likewise, the analysis of rainfall and VWC at a

[50] * Limited data available for analysis compared to VWC at 30 cm and VWC at 110 cm for Tallo Sigarche due to sensor failure.

depth of 110 cm for Mathillo Sigarche covered a period from 16th June to 8th September 2023 due to VWC sensor malfunctioning before that period [see Figure 7.5 (a)].

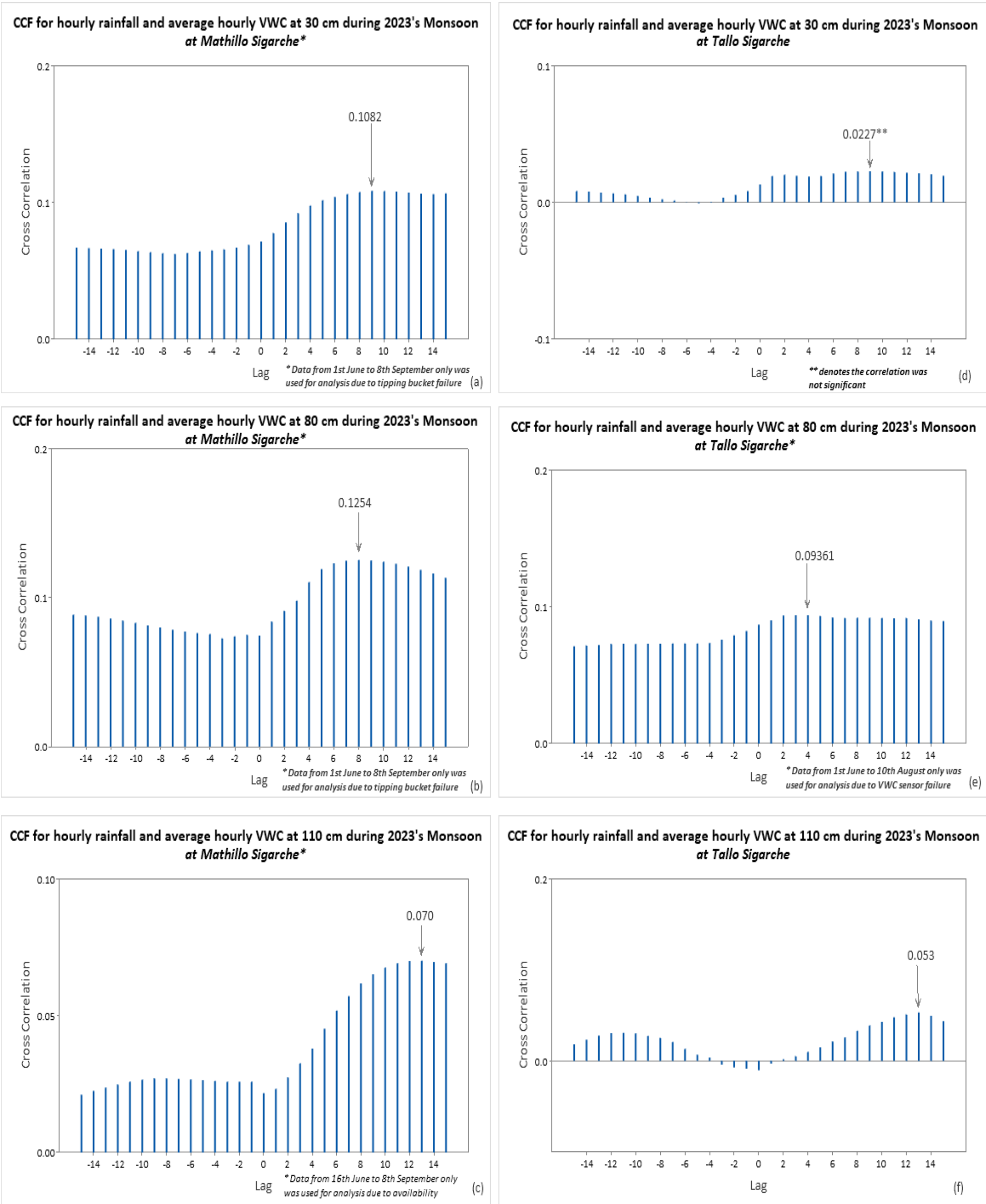


Figure 7.9: Cross-correlation function for hourly rainfall and average hourly Volumetric Water Content at different depths at Mathillo Sigarche (a, b, c) and Tallo Sigarche (d, e, f)

The longest lag observed between rainfall and VWC at 110 cm emphasizes the role of infiltration in controlling the water content at different depths. In summary, the data analysis shows that the volumetric water content (VWC) of soil in this type of setting depends on the seasonality, atmospheric drying and wetting, rainfall, the presence of surface cracks, preferential flow paths, and soil depth (Pradhan, 2021). The analysis also showed that the variations in soil moisture in response to rainfall at different depths, especially at greater depths, are not instantaneous (ibid). For example, the CCF between rainfall and VWC showed that it can take more than 12 hours of response-time for the VWC at 110 cm soil depths to respond to rainfall events.

A key takeaway message from this is the necessity of remaining vigilant to the potential risks of landslides even when rainfall has stopped for a day or more. Furthermore, previous studies suggest that it is not the rainfall, but the change in pore water pressure resulting from infiltration that causes a landslide (Toll et al., 2011). Therefore, efforts to minimize progressive infiltration to lower soil moisture, and to consequently prevent the loss of suction and shear strength could significantly reduce the risks of slope failure (Pradhan et al., 2020). This is where the indigenous strategy of reducing excess water on the hillslopes by channelling rainwater still holds immense practical relevance and importance (Rautela, 2020).

7.2.3 Patterns in Acoustic Emissions in relation to precipitation

As a part of the study, the Acoustic Emission (AE) data was considered in conjunction with precipitation data. For this, despite experiencing some gaps in the precipitation data for Tallo Sigarche in December 2022, and January and April 2023, the data was still utilized because the gaps occurred during drier months outside the monsoon. The decision was informed by the fairly strong positive correlation between the precipitation data of Mathillo Sigarche and Tallo Sigarche on overlapping dates as illustrated in Figure 7.10, with coefficient of determination (R-square) exceeding 0.8. The figure also shows that precipitation at Tallo Sigarche is ~73% that of Mathillo Sigarche. Rainfall monitoring instrument at Mathillo Sigarche had recorded no to very little rainfall in these missing periods. Hence, it was assumed that Tallo Sigarche might have experienced very little to no rainfall too, thereby causing limited impact on total rainfall and consequent slope deformation. This conclusion about period of low precipitation was also confirmed by the inhabitants of Tallo Sigarche.

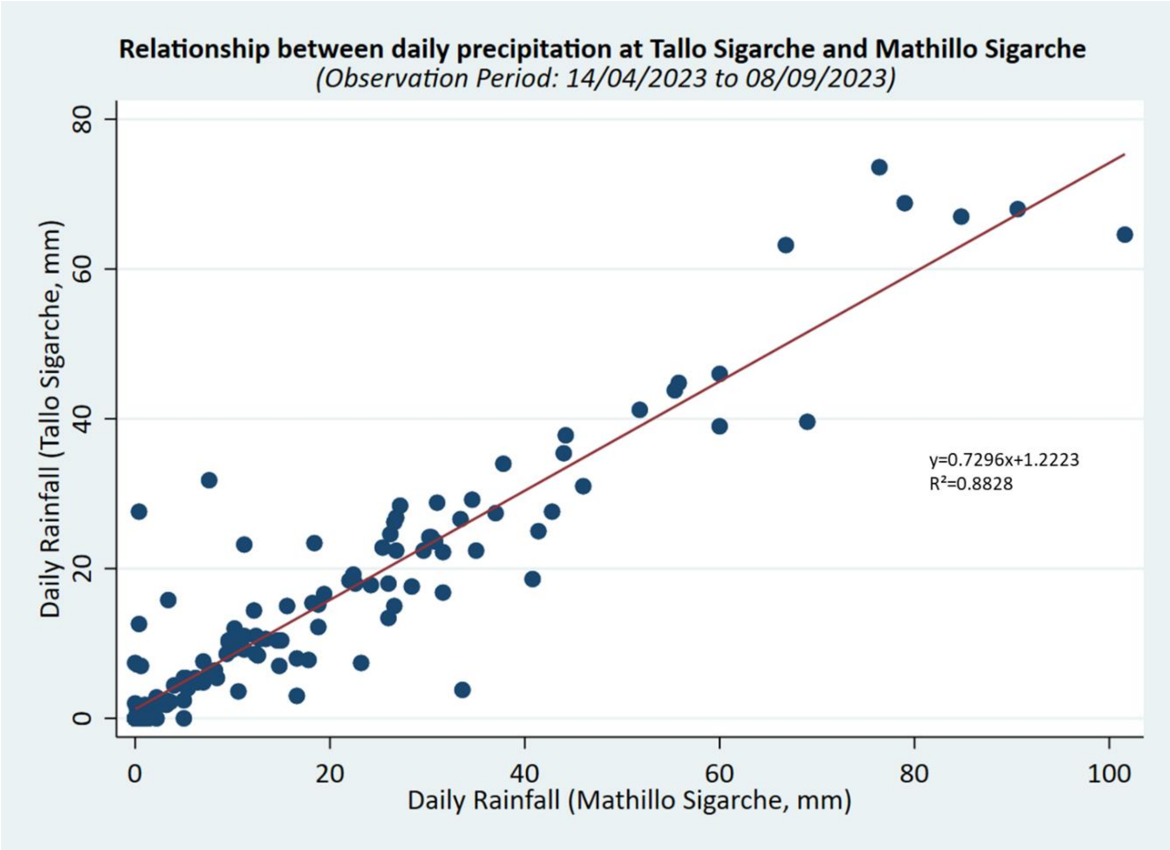


Figure 7.10: Relationship between Daily Precipitation at Mathillo Sigarche and Tallo Sigarche

The rate of generation and recording of AEs increases linearly with the rate of deformation (Dixon, Smith, et al., 2015; Dixon et al., 2018; Uhlemann et al., 2016). The data analysis showed that Tallo Sigarche experienced higher rates of acoustic emission as compared to Mathillo Sigarche during the observation period (see Figure 7.11). This is exemplified by the higher Ring Down Count (RDC)[51] values observed at Tallo Sigarche in comparison to Mathillo Sigarche. As seen in Figure 7.11 (a and c), AE generation at Mathillo Sigarche was very low throughout most of the winter until early February 2023 when the daily average temperature started to increase. Except for the marked occasional increase in AE rate on 7th May [marked as *Event A* in the Figure 7.11 (a) and (c)], the AE generation followed an 'S'-shaped cycle with a similar rate of cumulative AE until 13th June 2023 after which the rate reduced to near-zero values until a further increase after 15th July 2023. Interestingly, the near constant very low rate of AEs coincides the periods of rainfall early in the monsoon. This no to very low rates of

[51] Acoustic Emission rates were measured in the form of Ring Down Count (RDC) rates which are the number of times the AE waveform crosses a pre-defined voltage threshold levels within pre-set time intervals (Deng et al., 2023).

daily AE generation can be seen to be lagging behind the period when the average daily temperature started to decline indicating the potential role of temperature on AE generation, as has been observed elsewhere (see, for example, Smith et al., 2014).

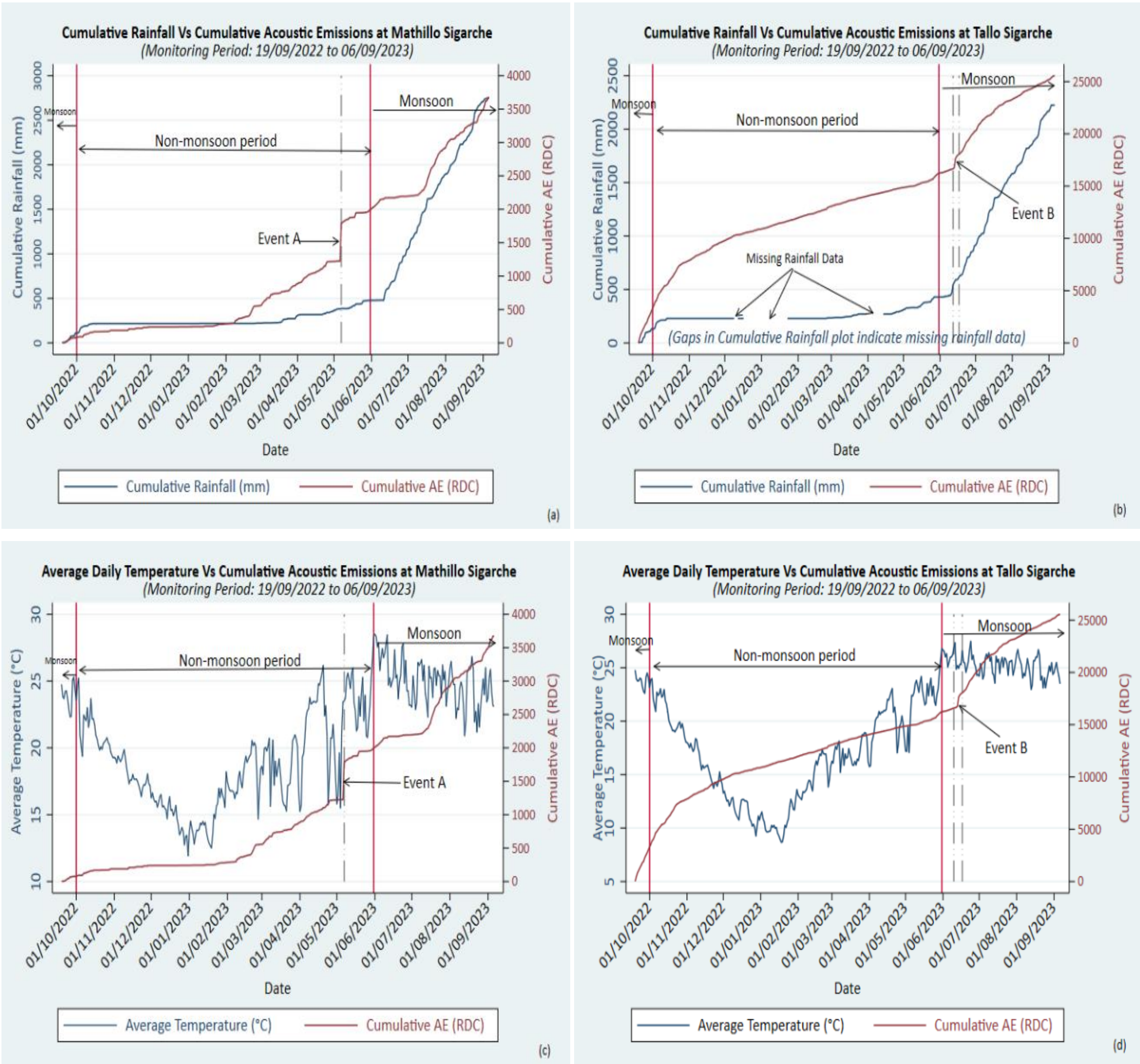


Figure 7.11: Cumulative Rainfall and Cumulative Acoustic Emissions at (a) Mathillo Sigarche and (b) Tallo Sigarche; and Average Daily Temperature and Cumulative Acoustic Emissions at (c) Mathillo Sigarche and (d) Tallo Sigarche

The increase in rates after 15th July lasted only for ~20 days. This is indicated by the decline in the rate of cumulative AE after around 4th of August. Daily AE rates appear to increase again from 28th August. Throughout the monitoring period, the AE does not appear of sufficient magnitude to indicate significant active deformation as compared to previous examples. For instance, Dixon, Smith, and colleagues (2015) characterized the AE generation of 2000 RDC/hour or higher as indicative of ‘very slow’ reactivation of slope movement at Players Crescent, Southampton, UK. Similarly, Dixon, Codeglia, et al. (2015), in their monitoring of rock slope deformation mechanisms at Passo della Morte in the Italian Alps, classified the AE trends with <1000 RDC/hour as low-rate events, 1,000-10,000 RDC/hour as medium-rate, and 10,000-100,000 RDC/hour as high-rate AE events. Likewise, Smith et al. (2017) underscored that the periods marked by increased AE rates could signify the initiation of landslide activity, and specifically highlighted that the AE generation surpassing 3000 RDC/hour corresponded with the periods of accelerated slope movement at Flat Cliffs, Filey in the UK.

The relative stability of the slopes monitored in my study was also reflected in observations made locally. Only some households opted for temporary relocation in the 2023 monsoon, and only then for a few days compared to far longer periods in previous years. According to local residents, they did not notice what they considered to be indicators of impending danger in this period.

Event A was further analysed at a higher temporal resolution to explore the potential reasons for AE generation during this period (see Figure 7.12). There was some rainfall on that day and a few days before. However, including the rainfall on the day when Event A occurred, this cumulatively amounted to less than 20 mm over the preceding 5 days. This rainfall amount is relatively insignificant compared to the wider period. Looking into the corresponding AE for periods with similar amounts of rainfall, Event A may not have been triggered by rainfall. Two possible explanations include: (1) local disturbances triggered by human activity or animal movement, but which the local informants were unaware of, and (2) the event could have been triggered by daily and hourly fluctuations of the temperature in the week when Event A occurred.

Figure 7.11 (c) shows that the daily average temperature dropped by around 4 degrees on 4th May and increased by ~8 degrees by 7th May. A closer look into the data surrounding the event dates suggests that hourly average temperatures had declined by ~7 degrees from the temperature in the previous hour [see Figure 7.12 (b)]. This could have led to the physical expansion and contraction of the infill materials, or the wave guide itself inducing the instantaneous generation of AE. Past studies (see, for example, Berg et al., 2018; Deng et al., 2023; Smith et al., 2014) have indicated the influence of background noise, sub-surface straining, seepage effects, infill materials, type of wave guide, properties of sensor's cover and temperature fluctuations in acoustic signal generation. There are ways to filter out some of the spurious noise, for example, by using an additional sensor at shallow depth (Berg et al., 2018) but such level of precision was not deemed necessary to achieve the objectives of this research.

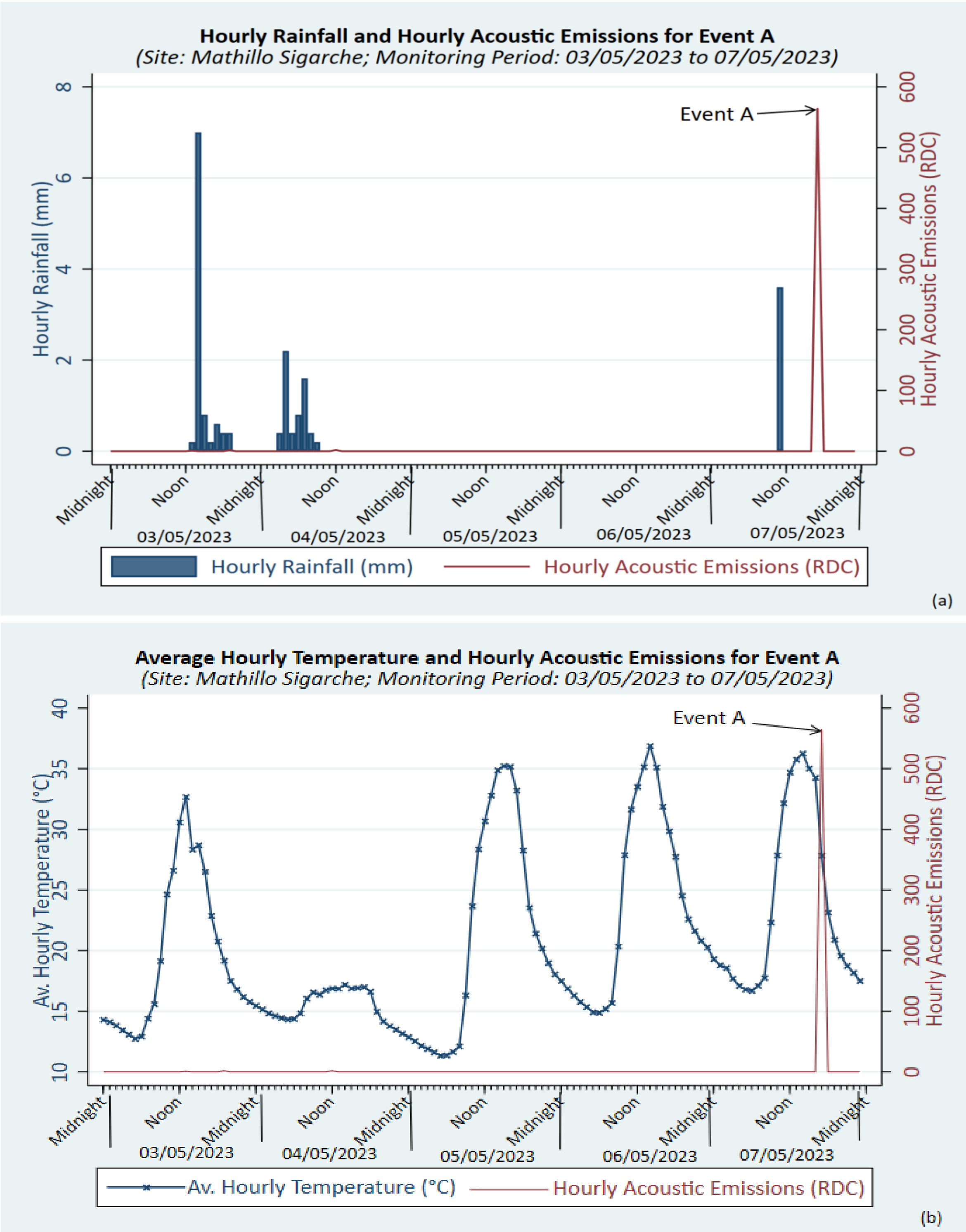


Figure 7.12: (a) Hourly Rainfall and Hourly Acoustic Emissions and (b) Average Hourly Temperature and Hourly Acoustic Emissions—around Event A

At Tallo Sigarche, as the 2022 winter progressed, the initial rate of AE declined but then increased steadily until a sudden increase after 14th June 2023, as marked by Event B in Figures 7.11 (b) and (d). Like Event A, event B was also analysed at higher temporal scale to explore this further [see Figure 7.13 (a) and (b)].

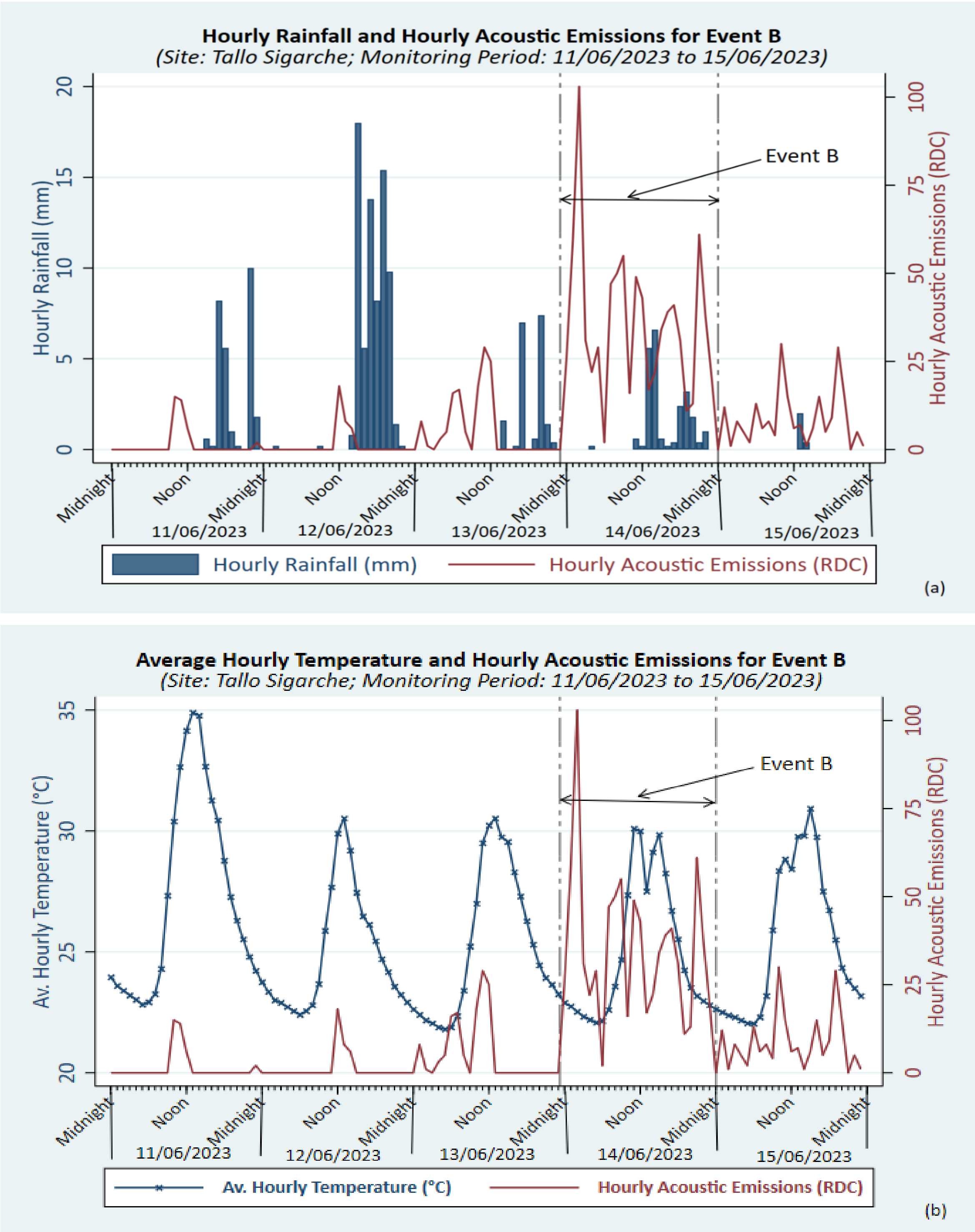


Figure 7.13: (a) Hourly Rainfall and Hourly Acoustic Emissions and (b) Average Hourly Temperature and Hourly Acoustic Emissions—around Event B

Figure 7.13 (a) shows that Event B was preceded by precipitation occurring between 11th and 14th June. It can be hypothesized that this rainfall might have triggered Event B. The continuous generation of lower rates of AE over extended periods, and the information from the local residents indicate that the site might have experienced smaller slumps or deformation on that day. After this event, the AE generation rates at Tallo Sigarche declined, yet the trend was still higher than in the winter and the pre-monsoon period [see Figure 7.11 (b) and (d)]. The increased AE generation rates lasted for around a month after which a decline in AE rates from around 18th July 2023 was observed.

To further evaluate the distribution of daily rates of AE generation, histograms have been prepared (Figures 7.14 and 7.15). Figure 7.14 indicates the generation of very low levels of AE at Mathillo Sigarche throughout the monitoring period indicating that the slope at Mathillo Sigarche remained stable. An event with daily AE > 500 RDC (Event A) had occurred at Mathillo Sigarche whose probable causes have been interpreted above.

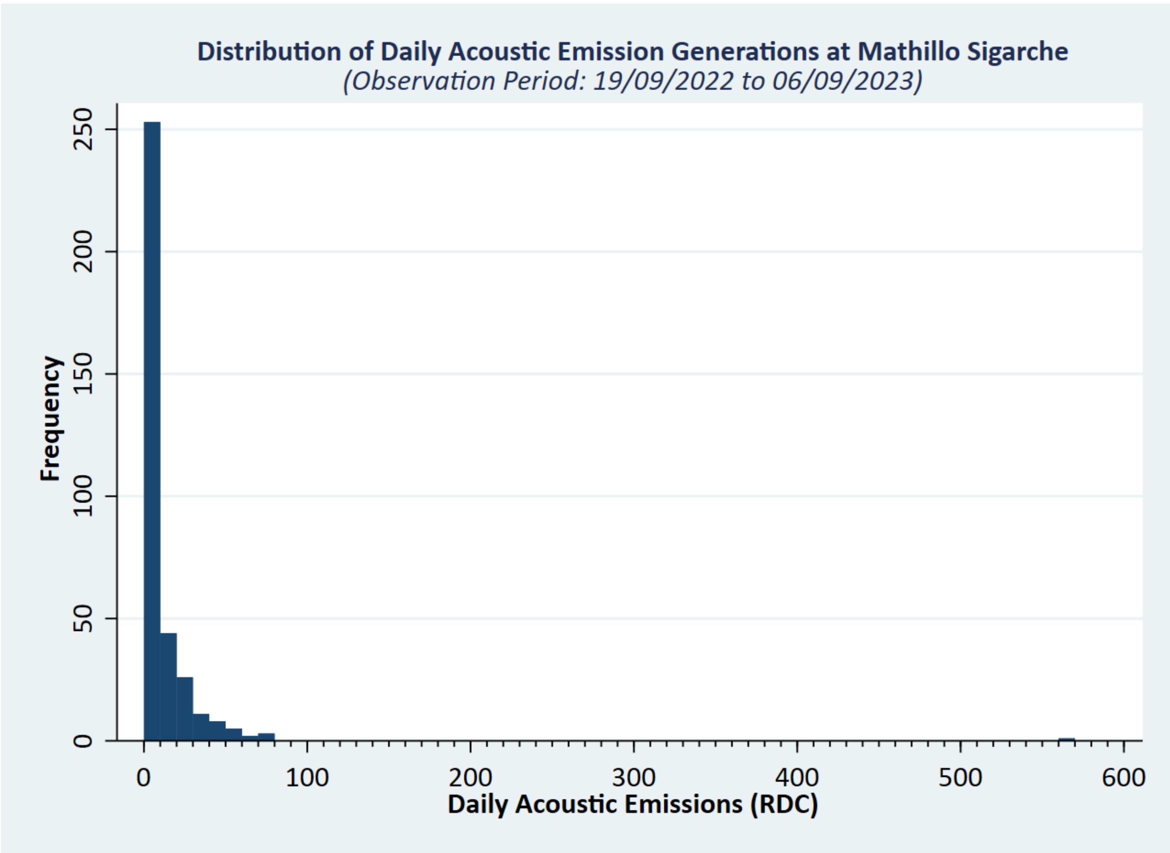


Figure 7.14: Distribution of daily acoustic emission generations at Mathillo Sigarche

Compared to Mathillo Sigarche, Tallo Sigarche experienced a higher proportion of the days with daily AE > 50 RDC (see Figure 7.15). The occurrence of smaller deformations through the monsoon, as discussed above, may have contributed to the generation of relatively higher rates of AE at Tallo Sigarche compared to at Mathillo Sigarche.

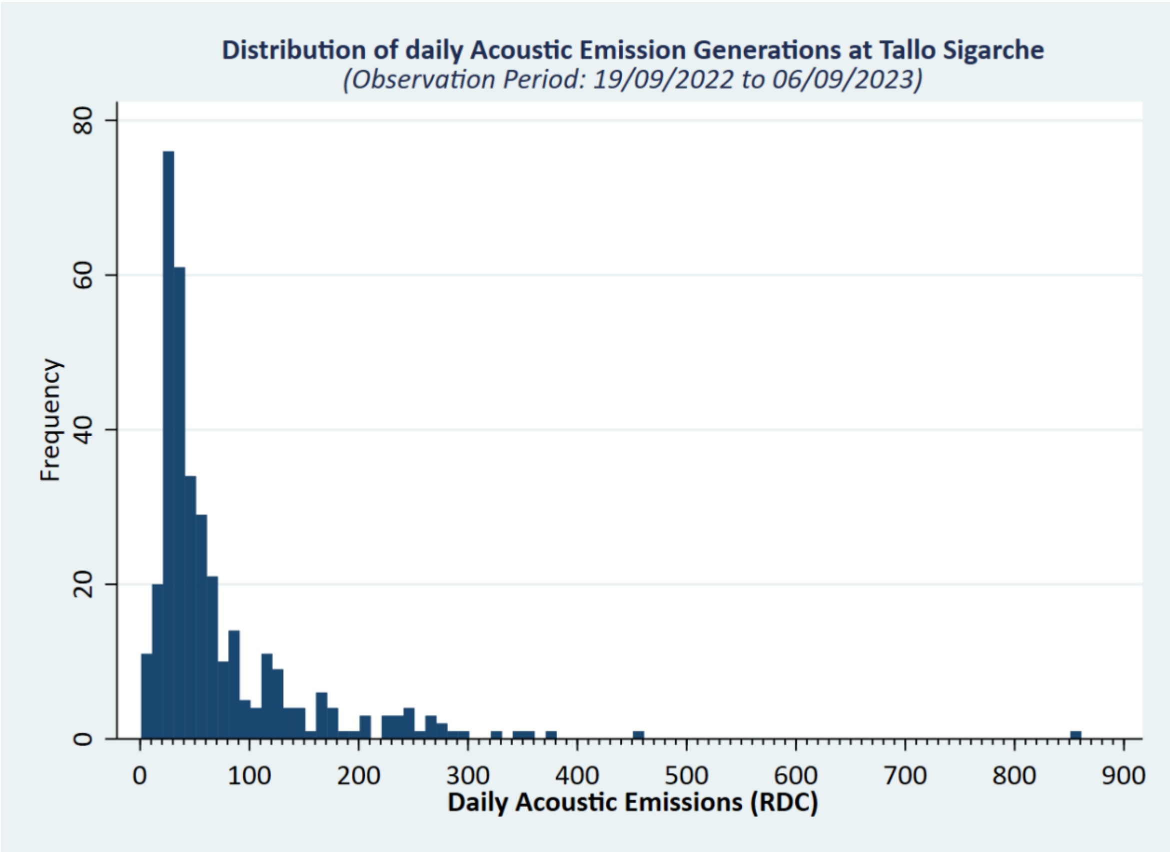


Figure 7.15: Distribution of daily acoustic emission generations at Tallo Sigarche

The amount of preceding rainfall, the VWC, and AE rates for times when the daily AE >= 250 RDC at Tallo Sigarche were further analysed, the findings of which have been summarized in Table 7.2. However, a similar analysis was not undertaken for Mathillo Sigarche because of the lower values of daily AE throughout the monitoring period, except for Event A. Importantly, Table 7.2 highlights that all days with daily AE => 250 RDC at Tallo Sigarche occurred during the monsoon[52], indicating seasonality in the generation of AE.

[52] Note: Monsoon withdrew from Nepal on 16th October in 2022. Hence, all the days shown in Table 7.2 lie within monsoon period.

The daily rainfall on days of all higher AE generation remained below DHM's 24-hour threshold of 140 mm/day. Ten out of 14 such events occurred when the seven-day cumulative rainfall was >60 mm. In future, it would be interesting to compare corresponding AE generation against official benchmarks for extreme rainfall events. It would also be interesting to compare the corresponding rainfall and antecedent rainfall, and VWC when the AE generation is indicative of active slope deformation.

Table 7.2: Patterns of Rainfall (RF), volumetric water content (VWC) and acoustic emissions (AE) at Tallo Sigarche when daily AE is equal to or greater than 250 Ring Down Counts (RDCs)

Daily AE (RDC)	Date of incidence	Corresponding RF on the event day	3 days RF	7 Days RF	10 Days RF	15 Days RF	Av. VWC at 110 cm	Av. VWC at 80 cm	Av. VWC at 30 cm	Av. Temperature inside the half oil drum
459	20/09/2022	3.4	13.8	69.8	NA	NA	0.405	0.399	NA	23.96
376	21/09/2022	1.2	7	48.6	NA	NA	0.405	0.399	NA	23.76
266	25/09/2022	41	87	94.8	127	NA	0.405	0.398	NA	23.20
360	27/09/2022	6.6	50	98	111.8	173.8	0.405	0.398	0.113	22.61
286	30/09/2022	22	27.2	85.4	125.2	163.2	0.404	0.395	0.107	24.08
262	01/10/2022	0	27	77.2	124	145.8	0.404	0.393	0.112	23.16
254	02/10/2022	0	22	36.2	123.2	139	0.404	0.392	0.109	23.88
326	03/10/2022	9.2	9.2	43	94.6	140.2	0.404	0.392	NA	23.97
280	05/10/2022	12.2	64.6	91.6	100.8	189.8	0.404	0.392	0.125	21.49
346	06/10/2022	7.4	62.8	94	105.8	196	0.404	0.392	0.154	20.91
266	15/10/2022	0	16	16.4	34.2	98.8	0.403	0.391	0.108	21.59
859	14/06/2023	23.2	115.4	151.8	160	160	0.397	0.411	0.368	24.95
278	23/06/2023	27.4	106.4	157.6	187	314	0.398	0.453	0.369	26.67
299	03/07/2023	39.6	63.6	162.6	218.6	338.8	0.399	0.462	0.371	24.99

Note: NA refers to data not available

Overall, in my research, the AE sensors demonstrated their good ability to continuously monitor even very small values of slope deformation at a very high temporal resolution (Dixon, Smith, et al., 2015). Although AE generation rates were not sufficiently high enough to indicate any catastrophic deformation during the monitoring period, the incidence of a small landslide nearby to the Tallo Sigarche monitoring site, as described by local residents, justifies the importance of continuing monitoring at both sites to better understand the slope behaviour in response to rainfall, soil moisture and hazard mitigation measures if implemented. In final sharing meetings held in March 2024, the local research collaborators from both Mathillo Sigarche and Tallo Sigarche expressed the benefits of and enthusiasm for continuing slope monitoring efforts in the future. To appreciate this, arrangements have been done to carry forward this endeavour through the Sajag-Nepal project.

7.3 Discussion

In this section, I discuss the overall experience of participatory landslide monitoring, and its contribution and potential in addressing gaps in landslide risk knowledge outlined in Chapter 6. I also reflect on the lessons learned that might be useful in future research.

7.3.1 Participatory landslide monitoring for knowledge co-production and risk reduction

The precipitation data suggested that more than 85% of the rainfall observed occurred during the monsoon. The difference in precipitation totals and patterns across the two sites, although being separately only by ca. 1 km, highlight that precipitation can vary considerably over very short distances. Past studies indicate a higher proportion of non-seismic landslide events during the monsoon, implying a strong relationship between broad measures of rainfall and landslide impacts (Froude & Petley, 2018; Petley et al., 2007). With climate change, extreme rainfall events are anticipated to increase (Karki et al., 2017). This might further increase the occurrence of rainfall-triggered landslides (Eyler et al., 2022). Hence, on the one hand, expanding the network of weather monitoring stations in data-scarce regions and improving the inventories of landslides to also include small-to-medium scale non-fatal landslides could help improve our understanding of landslide triggers. On the other, local government and civil society organizations should carry out essential precautionary preparedness and risk reduction measures in collaboration with the local communities before the onset of monsoon, which itself is ultimately predictable: perennial landslides should not come as a surprise.

As explained in Chapter 5, traditional practices such as the safe routing of surface water are being lost because of the combined effects of outmigration, a decline in mutual labour exchange (*parma*), the loss of the traditional customary *"Choho"* leadership, decline in the feeling of care for others, and local people's increasing detachment from agriculture due to landslides and crop damage caused by wild animals. As a result, the practice of diverting surface water directly towards roads is increasing. Consequently, the risk of landslides being triggered on weaker sections of the now extensive rural road network has increased. The local DRR and annual development plans should acknowledge these realities and plan measures to promote local people's engagement in drainage management.

People's perception of an extended or extending monsoon in recent years has here matched with the delayed withdrawal of the monsoon in both 2022 and 2023. My data suggests that during the monsoon, the AE and the VWC at different depths is higher than during the rest of the year. The implication is that local government and road construction users' committees should where possible avoid road construction, expansion or maintenance using heavy equipment during the monsoon months when the VWC is high, meaning a decrease in cohesion and the overall strength of the slope. This necessitates a significant departure from the tendency of *'Asare Bikas',* which refers to the last-minute rush to exhaust budget allocated for development interventions during the final Nepali month of each fiscal year[53], often resulting in substandard work quality and corruption (Chitrakar, 2019). The propensity for *'Asare Bikas'* may not only escalate the risks of slope failure in hilly landscapes but as revealed in my conversations with people from Mathillo Sigarche, also jeopardizes the credibility of local government and users' committees amongst local residents. For instance, in the recent past in Mathillo Sigarche, the operation of heavy equipment during the night in the monsoon had further increased public mistrust on local authorities. The road construction should be properly designed and informed with both local knowledge and technical input to ensure the local geological, socio-economic, and hydro-meteorological conditions are properly incorporated (Dahal et al., 2006; McAdoo et al., 2018; Sudmeier-Rieux et al., 2019).

The CCF analysis between rainfall and VWC at different depths showed the strongest correlation between rainfall and VWC at 110 cm at a time-lag of ~13 hours. This information could be useful to understand and convey that even after the cessation of rainfall during the monsoon, risks persist for extended periods. For at least 1 day after a rainfall event, people should exercise caution whilst navigating landslide-susceptible zones.

In the absence of extreme rainfall and highly active slope deformation, a robust relationship between the rainfall, acoustic emissions, and slope deformations, as targeted at the beginning of the research, could not be established. Put simply, the rainfall was not intense or sustained enough, and the slopes did not move in response. Incorporation of future extreme weather events or slope deformation episodes would enrich the findings and help establish the

[53] 'Asare Bikas' comprises two Nepali words: Asar and Bikas. Asar indicates the last month of Nepali Fiscal Year that overlaps with the onset of monsoon season, whereas Bikas is a Nepali term for development.

sensitivity of the approach developed here. For my sites, continued monitoring and engagement has been planned through the ongoing Sajag-Nepal project. Although there was no active deformation observed, my research has demonstrated that landslide monitoring using weather and AE is promising for site-specific landslide monitoring.

There are a variety of other ways in which the existing data might be considered useful. During the research, the most common query I received from the local residents and stakeholders was about the status of slope (in)stability. The overall lower levels of hourly and daily AEs, indicating the stable slope conditions at both sites, could be used to assure local people of lower landslide risks at present. Nevertheless, the rise in the rate of AE generation during the monsoon indicates the seasonal nature of deformation and its possible linkage with precipitation as well as the lagged and accumulative build-up of pore water pressures, highlighting the need for caution during the monsoon.

At Tallo Sigarche, there were 14 events when the daily AE was greater than 250 RDC and these all occurred either during the monsoon or in the month following the monsoon (October). AE generated in October coincided with an extended monsoon period withdrawal[54]. However, not all these events coincided with large precipitation events (see Table 7.2/Figure 7.16). Although these events are not of a magnitude that indicates active deformation, based on observations of the site during the monsoon and information from local residents, it can be assumed that the possible trigger of those events at Tallo Sigarche could be related to the incidences of smaller slumps during different times of the normal monsoon (June-September) and the extended monsoon period (October). A quote from a local resident pointing out a slump that had occurred a few terraces above the slope monitoring equipment exemplifies the nature and scale of smaller movements:

"…Seasonal water sprouts appear at multiple locations in monsoon along this slope. The precipitation does not need to be heavy. Drizzle for prolonged period can saturate the soil and result in slumps. Numerous such slumps occur during monsoon." (Krishna Basnet, Tallo Sigarche, Male, 45 years, Personal conversation, 2023)

[54] According to Department of Hydrology and Meteorology, monsoon withdrew on 16th October in 2022 from Nepal.

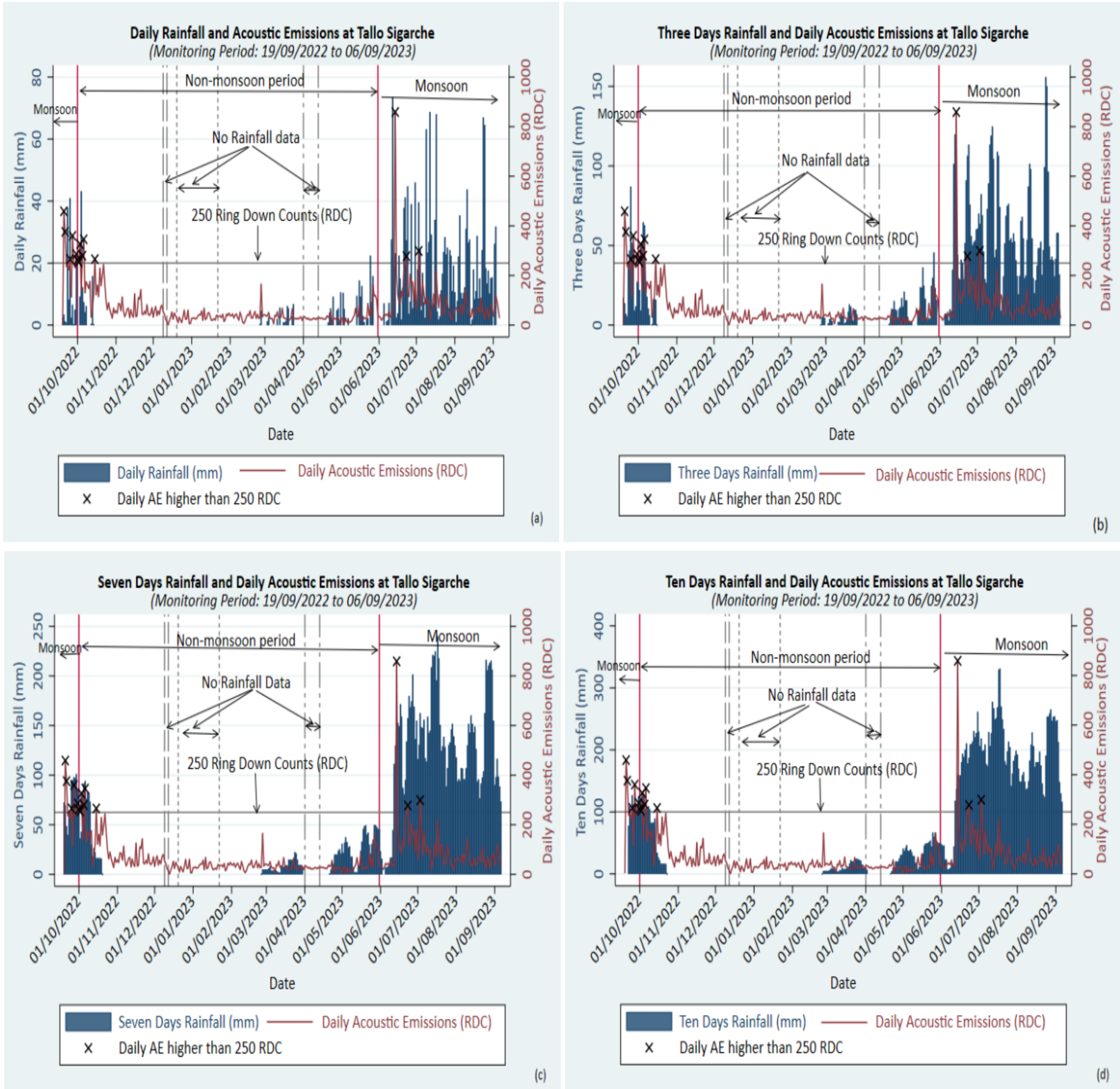


Figure 7.16: Daily Acoustic Emissions and (a) Daily Rainfall, (b) Three days Rainfall, (c) Seven Days Rainfall and (d) Ten Days Rainfall at Tallo Sigarche

The above quote not only exemplifies the abundance of slumps on the slope during the monsoon, but also the clear ability of 'uncertified' scientists to interpret the physical aspects based on their experiential knowledge. Such small slumps (see Figure 7.17) represent the fragile nature of the slope and the possibility for bigger slides in the future if not treated properly (Samia et al., 2017; Thapa et al., 2023). Hence, continued monitoring is essential to evaluate how slope deformation progresses. Likewise, precipitation data such as that collected here could also be used as evidence to advocate for relief and risk sensitive planning with public authorities and civil society organizations, and could help support communities not only when the problems of landslides arise due to too much water, but also when the precipitation is less than normal, such as that of the 2022/23 winter that caused serious impacts on the crop harvest.

Figure 7.17: Smaller slumps and slides common during monsoon along the slope monitored in Tallo Sigarche

The participatory landslide monitoring, using weather data and AE sensors, also provided a good platform for community dialogue. The conversations and discussions throughout the project were insightful and informed the selection of sites for monitoring as well as my understanding of the types of data of interest (see Sections 6.5.2 and 6.5.3). A useful insight was the (in)accessibility and limitations of current government advisories issued about landslides (see Section 6.3). Almost all participants were unaware of the existence of such advisories, and when they were shown the sample, they were not able to contextualize the risk for their own settlement. In such situations, the communicated risk information could be misinterpreted or even ignored. Rollason and colleagues (2018) studied the dynamics of risk communication in the contexts of flood risks in Northumberland, UK, and discussed the causes and repercussions of misinterpreting risk information. Their study offers useful insights into the factors influencing communication misinterpretation, aiding a deeper understanding of its implications.

The meetings with local residents were also used to discuss the historical timeline of different landslides and their impacts, their perceived causes and indicators, and efforts to cope with and mitigate landslides. These discussions were useful to validate the information gathered during the preceding ethnographic engagement summarized in Chapter 5. I also facilitated discussions about the institutional provisions for landslide risk reduction. Notably in Mathillo Sigarche, we discussed and explored some potential ways to address issues related to landslides and 'everyday' risks. These include raising a collective voice against haphazard road construction and exploring resources for making temporary shelters. In both cases, local residents achieved some successes. During my field visit to Mathillo Sigarche in June 2023 to download the AE data and to replace a VWC sensor, people explained that they had strongly opposed a proposal to construct a rural road through the terraces above the landslide monitoring site, which they considered unstable. They also mentioned that after approaching some public, private, and civil society organizations, including the ward and municipal representatives, an individual donor provided them with tarpaulins for building temporary shelters in the 2023's monsoon. Though this represents a small level of support compared to the scale of the issues faced, they considered that this has boosted their confidence. They felt that the relationship built with different people and service providers could be used to draw in the larger resources needed to address landslide and livelihood issues in the village.

At Tallo Sigarche, local people cemented the base and sides of key drains to prevent infiltration and pore water pressure build-up in the slope (see Figure 7.18). I found sustained discussion about landslide related issues, even if not necessarily related to landslide monitoring, helped to keep the group connected and active during periods when there was little to discuss about the landslide monitoring itself. I feel this helped to strengthen the trust and relationship between myself and my participants.

Although the AE data suggested that the monitored slopes were not actively deforming, one should refrain from forming a negative 'threat appraisal' (Rogers, 1975; Rollason et al., 2018) by assuming that the slopes will not deform in future (Rosser et al., 2021). Albeit of a smaller magnitude, the data showed a clear increase in cumulative AE during the monsoon indicating the sensitivity of slopes to rainfall and porewater pressure build-up. People could use the rainfall, soil moisture and AE data to highlight with local government and stakeholders about the sensitivity of the slopes in their locality, and therefore for the need to avoid haphazard development, particularly in the monsoon. Continuation of monitoring how the AE and slope stability respond to rainfall and soil moisture in future will improve our understanding, while the safe disposal of surface water and measures to lower sub-surface and ground water would clearly be useful at both sites.

In the future, provisioning remote access to real-time AE, akin to the rainfall and soil moisture data, would eliminate the need for on-site visits for data downloads and subsequent analysis. This would facilitate quicker analysis and dissemination of up-to-date data, allowing local residents and stakeholders to make informed decisions regarding temporary relocation and implementation of appropriate risk reduction measures.

Figure 7.18: A drain cemented on base and sides to minimize infiltration and diverted towards natural rivulet in Tallo Sigarche

7.3.2 Addressing knowledge gaps

In this section, I reflect on the extent to which my research on participatory landslide monitoring has contributed to addressing each of the knowledge gaps detailed in Section 6.3. The reflections presented in this section stem primarily from the discussions held during the final sharing meetings conducted in March 2024. However, they are also informed by the ongoing insights gained during my ethnographic fieldwork and overall research journey.

i. Residents have a lesser understanding of landslides in areas outside their sight

My research has demonstrated that installing rainfall, soil moisture and acoustic emissions sensors in areas not readily visible from people's usual places of residence or regular activity areas can gather invaluable information about (re)activation and progression of landslides. The sensors used in this research can collect the rainfall, soil moisture and acoustic emission data continuously at a high temporal resolution, and hence can help residents understand the status and risks of slope deformation in such areas. However, sole reliance on technical instruments should be avoided, and the provisions of regular check-up, maintenance, and necessary triangulation with local observation should be ensured for better outcomes (Michoud et al., 2013).

ii. Subsurface slope conditions are not well understood

As presented in Section 7.2 above, the monitored data provided useful insights in terms of how the VWC/soil moisture and AE can be influenced by the seasons, rainfall characteristics, local site conditions, the ground water table, preferential flow path, depth from the soil surface, and atmospheric drying and wetting processes. As such, the inclusion of soil moisture sensors at different depths (Pradhan, 2021) and AE sensor (Dixon et al., 2018) for landslide monitoring helps to better understand the subsurface conditions of the slopes of concern. The following quote from a local resident from Mathillo Sigarche after the final sharing meeting conducted in March 2024 highlights what involvement in participatory landslide monitoring could offer:

"… I liked the discussion on how soil moisture at various depths can continue to increase even the rainfall ceases, creating conditions for landslide initiation. I also could totally relate how we have resorted towards diverting surface run-off directly onto the roads instead of employing traditional methods of run-off disposal. Our ancestors used their wisdom to reduce infiltration and soil moisture on slopes by constructing a network of side-drains to dispose rainwater toward nearby stream channels. Unfortunately, we have begun to overlook such

*valuable knowledge, thereby increasing risks of landslides." (*Purna Bahadur Tamang, Male, 35 years, final sharing meeting, Mathillo Sigarche, 2024)

iii. Current government advisories for landslides do not meet householders' or communities' needs

My research shows that the use of AE sensors alongside rainfall and soil moisture monitoring increases the accuracy, geographic specificity, and reliability of the landslide monitoring system. Unlike the generalized weather forecasts included in government advisories, householders were found to be more interested in knowing about the weather and slope deformation conditions with higher temporal and spatial precisions and accuracies. The participatory monitoring carried out in this research directly addresses this issue at site-specific levels:

"We are happy that we have a monitoring station in our village. The data is far more accurate than what we receive from radio broadcasts or government advisories." (Prabhu Tamang, Male, 34 years, final sharing meeting, Tallo Sigarche, 2024)

For a broader geographic scale, in future, the collective insights gained from the longer-term data from my research sites and eight other sites monitored by Sajag-Nepal (https://www.sajag-nepal.org/) project across Nepal using similar instrumentations and approaches, could be useful to improve the reliability and specificity of government advisories.

iv. Perceptions of rainfall characteristics and slope deformation are inconsistent

Section 7.2 presented the results of the overall, seasonal, weekly, and daily patterns of rainfall, soil moisture and AE data. The preliminary findings were shared with the local people via my Youtube video created and uploaded in June 2023 (Shrestha, 2023) which was watched more than 200 times by December 2023. In March 2024, I conducted visits to the study areas for final sharing of my research findings. It was exciting to receive positive feedback regarding the advantages of participatory landslide monitoring as illustrated in the following quotation:

"We initially assessed the rainfall frequency and patterns based on our engagement in paddy plantation and associated preparations. However, comparison of our observations with

instrumental data showed discrepancies with the actual conditions. Such inconsistency could be due to our reduced attention to the rainfall patterns after completing the plantation works. Additionally, this could also be due to our regular travel outside the village after the completion of agricultural tasks…. By engaging in landslide monitoring and related discussions, we have understood the importance of comprehending rainfall characteristics beyond their relevance to paddy cultivation. We now recognize the importance of understanding rainfall characteristics in both preparing for and mitigating landslide risks." (Sunita Basnet, Female, 39 years, final sharing meeting, Tallo Sigarche, 2024)

Based on my research experience and findings, for future research, I recommend to engage local people in maintaining weather diaries to note key observations (LaFay, 2023), and to compare these with instrumental data to explore if such cross-validation helps in bringing consensus in perceptions around weather characteristics and corresponding slope deformation status (Malone et al., 2022), where the latter has typically been challenging to capture in a reliable manner. This will aid in a more systematic evaluation of the effectiveness of landslide monitoring data in reducing the divergence in local perceptions around rainfall patterns and landsliding.

v. Most landslide monitoring measures undertake rainfall monitoring only and do not monitor the precursors of landslides

My research and data suggest that higher AE generation rates did not always coincide with or follow rainfall events. This highlights the challenges and limitations of using rainfall only in landslide forecasting and monitoring. Furthermore, the ongoing collection of AE data for almost a year, during period considered for analysis, without any data gap demonstrates the suitability of this technique to detect even small-scale slope movements at a very high temporal resolution (Dixon, Smith, et al., 2015). Overall, this research demonstrates the huge potential of including parameters such as VWC and AE alongside rainfall in identifying the precursory signals of slope failures ahead of the main catastrophic failure, given the complexities of the links between rainfall and landsliding. However, continued monitoring is recommended to determine what VWC values and AE rates represent a precursory benchmark or threshold for a potential landslide, if at all (Dixon, Codeglia, et al., 2015; Stähli et al., 2015).

vi. Local governments lack low-cost measures for landslide risk reduction

This research has illustrated that employing participatory approaches for landslide monitoring using sensors for monitoring rainfall, VWC and AE has the potential to collect continuous useful data at high level of temporal granularity. The total cost for sensor purchases and installations per site (including the cost of galvanized iron tubes used as wave guides and other materials needed for installations, cost of fencing around the site, and drilling) was around 6000 USD—equivalent to less than 0.2% of annual budget of the municipality under study (Barhabise Municipality, 2021). In comparison to other more expensive structural measures like gabion walls construction for landslide mitigation, this cost is notably lower. With local vendors emerging and offering comparable sensors, there are opportunities for even lower costs. Additionally, engaging local vendors and service providers presents the opportunity for quicker solutions to technical problems when they arise.

While the weather station encountered some technical issues, such as network issues and sometimes the sensor failure, the AE sensor performed well without any technical issues during the monitoring period. As this research demonstrates, the data collected by these sensors could be immensely valuable in fostering a shared understanding of the landslide risk and evolution, and for guiding both public and institutional decisions regarding broader risk reduction measures.

vii. Lack of trust in science and 'outsiders'

As highlighted in Chapter 5 and in Section 6.4 of Chapter 6, my year-long ethnographic engagement[55] with community members conducted prior to the participatory landslide monitoring was crucial in understanding local context, values, and power dynamics. The knowledge production was aimed at exploring what people considered useful or significant. This included choosing the monitoring sites where people expressed concerns about the risk of slope movement and conducting data analysis to evaluate what information people considered it useful to know, or to be aware of. Even when face-to-face interactions was constrained by the COVID-19 pandemic, or when I returned to UK for data analysis and write-

[55] This period includes period of virtual engagement via phone, Facebook messenger, Viber and WhatsApp calls and 11 months of on-site ethnographic works.

up, I remained in touch with my local collaborators online. Such virtual conversations had some practical challenges associated with time or access to mobile phones and internet facilities, but the benefits outweighed the effort and challenges.

Overall, this research underscores the importance of dedicating time to comprehend the context, maintaining regular communication and engaging in active listening as emphasized by Antweiler (2004) as key in building trust. The absence of physical damage to the monitoring instruments in more than 1.5 years of installation, and the expression of commitment to continue collaboration in sustaining participatory monitoring are indication of people's trust in me and the research being conducted. To earn trust, the discussions with local people and attention should not be confined to the research focus but should encompass more general topics that people value or deem important (Stone et al., 2014). As an example, through this research collaboration, our involvement extended beyond the landslide monitoring. We also explored and secured funds for tarpaulins to be used in the monsoon for creating temporary makeshift shelters.

7.3.3 Considerations for the continuation or replication of this research

This research has captured lessons that could be useful for future continuation or replication of similar work. I found the ethnographic engagement and the associated 'small talk' (Driessen & Jansen, 2013) invaluable in maintaining a connection with local people, and to confirm instrumental observations when needed. Local collaborators also helped maintain the sites, clearing obstructions to the solar panels, and cleaning the tipping bucket rain gauge. An important lesson is that future research should invest in building strong relationships not only through face-to-face interactions, but also by making use of virtual means of communication when there are gaps in direct interactions. As for wider participatory action research efforts, comparable research will demand not only the technical skills but also the patience, social skills, flexibility and longer timeframes needed (Whitman et al., 2015).

This research also showed the benefits of engaging participants in other landslide and 'everyday' issues, beyond the core focus of my research. Based on my experience, in future similar or comparable research, the periods of quiescence could be used to discuss such 'everyday' issues of concern with local people. This helps to strengthen the relationships between the researcher and participants, and to boost the motivation for continued participation.

However, my research regularly lost key participants. While careful attention was given to involving motivated participants, seasonal (intra-country) and longer-term (inter-country) outmigration, which is a reality in contemporary Nepal (Campbell, 2018; Ensor et al., 2019), impacted my research. While addressing this issue was beyond the scope of my research, future projects should consider allocating funds and developing strategies to generate or tie in with some local livelihood opportunities for research participants to compensate for their time contribution (Gladfelter, 2018).

Besides these people-centric considerations, this research has also captured some lessons regarding the technical aspects of landslides research in Nepal. Upon demand from my research participants for easy access to real-time weather information, we created an online dashboard to allow direct access to the live weather data (see https://dashboard.hobolink.com/users/3902/dashboards#/dockey/BDFA5D9B83A35E98562936BB4735B10D). The screenshots of the dashboard are presented in Figures 7.19 and 7.20. However, the research participants found our interface complicated to interpret. Due to time-constraints, little could be done to improve this. Future research should be more participatory and consultative in customizing methods for information communication and dissemination in addition to collection.

The weather and soil moisture monitoring equipment encountered several technical issues, prompting replacement of the Hobo data logger at both sites, tipping bucket rain gauge at one site, as well as the replacement of three VWC sensors. This demands the necessity for a mechanism to routinely check the instrument status, and to undertake repairs as necessary. At times, the loggers did not post data to the Hobolink platform, perhaps due to GSM network issues. Issues related to poor networks or insufficient data credit for data transmission are not uncommon in such systems. Future monitoring could consider using a logger with the options to use multiple mobile networks, to enhance the continuity of communication by minimizing the network issues. Our research also showed relying solely on the technological approaches is not sensible (Rai & Khawas, 2019; Vasileiou et al., 2022). Instead, combining human and technological observations improves data collection and cross-validation (Hilhorst et al., 2015) and results in a more complete hazard understanding (Malone et al., 2022).

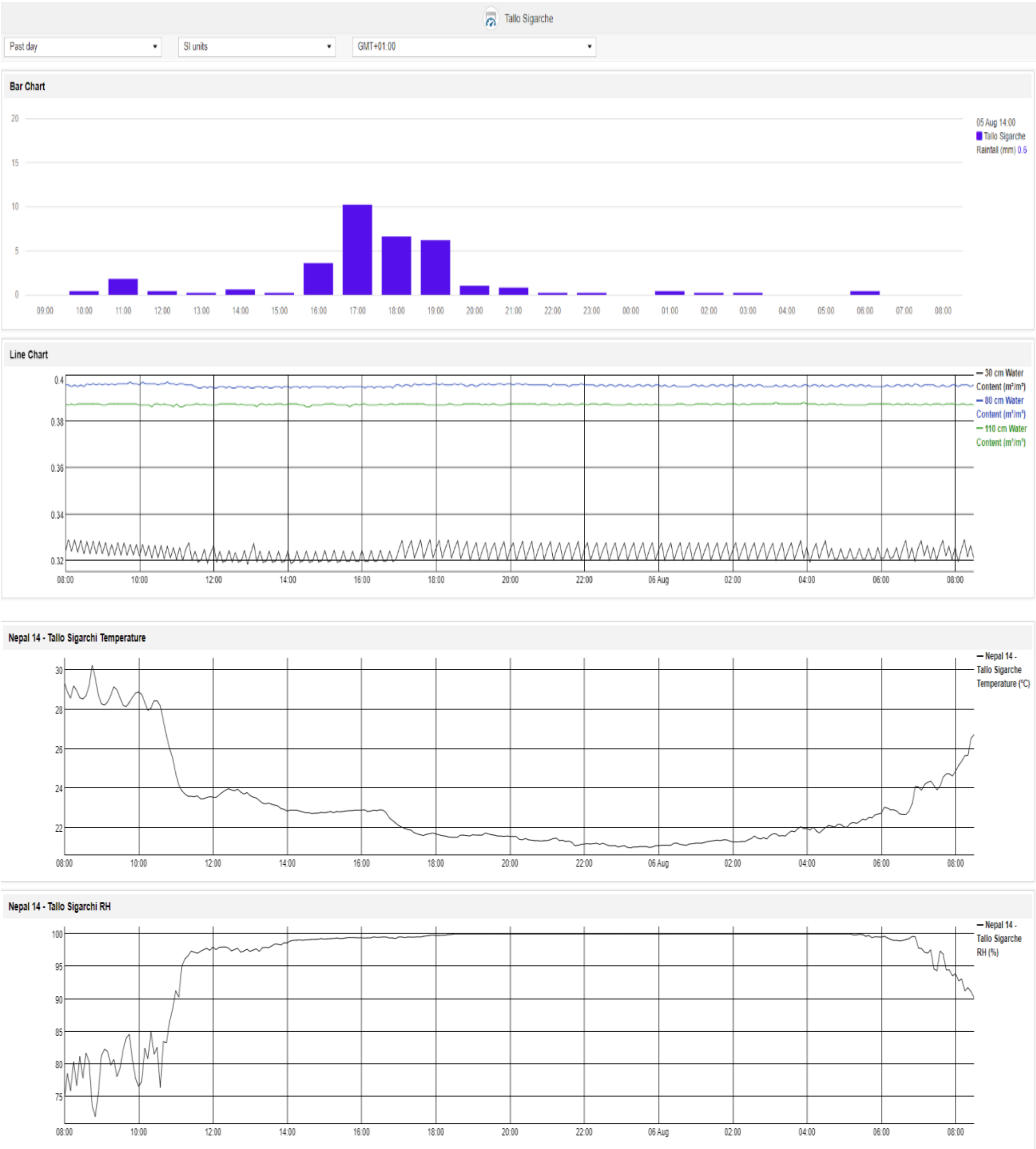


Figure 7.19: Screenshot of dashboard showing sub-daily rainfall, soil moisture, temperature and relative humidity patterns

Figure 7.20: Screenshot of dashboard showing daily rainfall, soil moisture, temperature and relative humidity patterns over a week

Future monitoring using AE could incorporate mechanisms for remote access to the data generated, and to provide a power back-up system to run the system. Throughout the research, a regular question from local residents was around the status of slope stability. Primarily for cost-related reasons, we had not incorporated a communication system that supports remote access to the AE data. However, this caused delays in data collection, analysis, and dissemination. Transmission of live data via an online platform would ensure remote access to data and quicker analysis and interpretation than attained in the current research. Furthermore, it would ensure that the data are not lost even though the loggers are buried or damaged when a landslide occurs. Additionally, integration of solar panels to charge the acoustic emission sensor battery would offer an additional layer of assurance in ensuring power backup.

The risk of landslides may vary over very small distances (Rosser et al., 2021). While the location of sensors was chosen as a function of a range of factors, the decision making around location can be complemented by the analysis of satellite imageries (Eyler et al., 2022; Kincey et al., 2021) and other monitoring methods such as Real-Time Kinematic (RTK) GPS monitoring of deformation (Huang et al., 2023) where applicable, for identifying the most sensitive areas within a slope for installing AE sensors. However, this may involve additional expertise and resources.

7.4 Conclusions

My research intentionally foregrounded the active engagement of local people in participatory landslide monitoring. This is different to other approaches which tend to be led by 'certified' scientists or outsiders with a minimal genuine role of 'uncertified' scientists or local people (Acuña et al., 2021; Alcántara-Ayala, 2016). Despite the challenges brought about by the COVID-19 pandemic, the research was informed by local people's insights and inputs. Though the research participants had a limited role in the selection of the actual monitoring technology used, their role in narrowing down where the monitoring would be most effective and what sort of data might be useful guided the entire undertaking. Their involvement was crucial in rolling out the installation, repairing/replacing the sensors, and resolving occasional doubts, conflicts and grievances that arose within and from nearby communities. Their input was key in ensuring the safety and functioning of the instruments at sites in my absence, and their observations were crucial in verifying anomalous instrument readings and filling data gaps.

Knowledge about the weather patterns and slope stability were generated by combing local knowledges and scientific information in discussions of the data. This study also utilized the opportunities provided by digital platforms such as Facebook Messenger and Youtube to communicate with local people and to triangulate data and disseminate findings during times such as the pandemic, or when my direct presence was not possible. Such approaches were useful in enabling virtual data collection and sharing, and in strengthening relationships and building trust.

The participatory landslide monitoring was found to be a promising way of discussing landslide issues and potential solutions. The discussions using instrumental and observational data showed the effectiveness and potential to generate shared understandings of hazards. Overall, this research has given some hope that the slopes can 'speak' of their instability by integrating the locally specific instrumental data and local observations. Continuation of monitoring for at least a year more has been planned through the Sajag-Nepal Project. The next steps include exploring how decision makers could be made more accountable to people's risks and vulnerabilities using the slope monitoring data as a 'boundary object' for facilitating discussions and collaboration (Enqvist et al., 2018). This, in other words, is to explore ways to give local people a voice and to ensure their problems are seen and heard by the decision makers.

Chapter 8 Discussions and Conclusions

8.1 Introduction

This thesis has undertaken interdisciplinary research with the aim to understand the underlying vulnerability of one of Nepal's historically most marginalized groups - the *Tamang* - to the risks of landslides. For this, I adopted a combined political ecology and cultural lenses based around ethnographic engagement with the community members living amongst landslides. My aim was to better understand the bio-physical and socio-economic causation of vulnerability and to explore the knowledge and practices adopted to deal with day-to-day landslides. The ethnographic fieldwork built upon a systematic literature review of studies of 'self-driven' and 'community-based' landslide risk reduction measures. The research also piloted a way to integrate 'outsider' knowledge with that of 'insiders' to co-develop politically- and socio-culturally informed landslide risk monitoring system at my study sites.

My research tackled three research questions. The first question unpicked the reasons for success and failure of community-based landslide risk reduction efforts. To do this, I conducted a systematic mapping and review of examples of 'self-driven' and 'community-based' landslide risk reduction approaches (Chapter 4). The second research question explored different knowledges and strategies for landslide risk reduction within Tamang communities, and the socio-cultural institutions and wider processes influencing those knowledges and strategies (Chapter 5). For this, in my fieldwork, I worked with a landslide prone community in a Tamang settlement in Sindhupalchok district, Nepal. Likewise, in my third and final research question, I explored the process and outcomes of co-producing knowledges generated using landslide monitoring, following a participatory action research approach with two communities in Sindhupalchok district (Chapters 6-7).

I conducted the retrospective review during the first and second wave of the COVID-19 pandemic (Chapter 4). Here I explored 'self-driven' household or community actions undertaken without external support. Similarly, I examined the 'community-based' landslide risk reduction measures implemented by or in communities with the assistance of external agencies, professionals, and researchers. The aim was to capture lessons on applicability and challenges of 'community-based' measures. I also scrutinized if such 'community-based' initiatives adequately consider the local context, needs, culture and power dynamics.

I commenced my ethnographic fieldwork in May 2021, which underpinned the research described in Chapter 5, and then provided the basis for Chapters 6 and 7. The fieldwork continued until October 2022 and included participant observation, informal conversations, semi-structured interviews, and focus group discussions. While Chapter 5 explored the socio-cultural and political processes influencing local knowledge and strategies, Chapter 6 presented the background preparatory works and processes, and the knowledge gaps underpinning participatory landslide monitoring component of my research. Similarly, Chapter 7 featured the patterns and interrelationship of rainfall, soil moisture and acoustic emissions data recorded over the observation period as well as reflected on the procedures and outcomes of participatory monitoring with emphasis on its contribution and potential for bridging the knowledge gaps in the sector.

This chapter is divided into three sections. I began by giving a brief background of the research questions and methodologies (Section 8.1), and present key reflections that build upon my research in Section 8.2. In doing so, I also present a broader reflection on key conceptual frameworks that underpin current work on DRR and knowledge integration (Section 8.2.4), in addition to considering the implications of this research for policy and action (Section 8.2.5). Finally, I end by presenting my conclusions and limitations, and make recommendations for further research (Section 8.3).

8.2 Discussion

8.2.1 The general nature of community-based landslide risk reduction measures: reflection from the systematic literature review

The review of self-driven approaches of landslide risk reduction (Chapter 4) highlighted that the people adopt multiple strategies to reduce the risks and impacts of landslides at household and community levels. However, risk reduction measures supported by the external agencies often do not fully incorporate local culture, knowledge, or existing often longstanding local strategies. In almost all cases, such factors were treated as being homogenous or irrelevant. Such potential undermining of local culture and knowledges in DRR measures can further escalate, rather than reduce, risks and vulnerability (IFRC, 2014; Kulatunga, 2010). In literature, a frequently used example of this is the case of 2010's Merapi Volcano in Indonesia that killed over 250 people, including the spiritual keeper of the volcano, *Mbah Maridjan*, who had refused to evacuate despite the official warnings from the government because he had not received premonitions of the eruption (Hewitt, 2011; Reyes et al., 2019). In another instance, Leach & Tadros (2014) highlighted how the Egyptian government's decision to cull pigs to control the H1N1 epidemic caused the further marginalization of minority *Coptic Christian Zabaleen* people whose lives and livelihoods were dependent on pig rearing.

These examples, although not specifically related to landslides, illustrate why it is important to work with people to incorporate local culture and knowledge into DRR. However, in most cases of CBLRR efforts reviewed, the participation of local people was limited to either 'consulting' and 'enticing' (Arnstein, 1969; Dyball et al., 2007) with only two out of fifty-eight studies showing a 'co-acting' mode of participation (Petterson, Nanayakkara, et al., 2020; Petterson, Wangchuk, et al., 2020). Such seemingly bottom-up but tokenistic participatory actions enforce 'participatory exclusions' (Agarwal, 2001) and can further institutionalize power asymmetries, benefiting elite interests rather than those of marginalized groups and households (Cooke & Kothari, 2001; Nagoda & Nightingale, 2017). Consequently, the degree of suspicion and distrust can further escalate (Klimeš et al., 2019; Wynne, 2006).

Another finding was the mismatch in priorities of households/communities and supporting agencies while designing and implementing DRR programmes (IFRC, 2014). Households, outside of situations with acute risks, are concerned about 'everyday' problems like food and their children's school fees (IFRC, 2014; Oven, 2009). In many cases, people rationalized landslide risk with livelihood and development opportunities (Oven & Rigg, 2015), rituals and religious beliefs (Ahmed, 2021; Ayeb-Karlsson et al., 2019), and place attachment and kinship (Oven et al., 2021). Repeated small-to-medium scale landslides that are not necessarily fatal but cause serious disruption ranked higher in people's priorities compared to the more severe but rare events (Ritu, 2020). However, both 'everyday' concerns and small-to-medium scale landslides hardly feature in most CBLRR efforts. In the absence of effective support from external agencies, poor and marginalized communities deal with these issues largely on their own, and often at the additional cost of self-well-being (Shrestha, 2016). Such situation was apparent in my study areas as well.

Despite growing calls for the importance of addressing the root causes of vulnerability (Oliver-Smith, 1996; Wisner et al., 2012), none of the studies reviewed involving community-based measures showed a deeper degree of engagement by supporting agencies in identifying and addressing the underlying root causes of vulnerability. In general, hidden socio-cultural dimensions of risk and vulnerability were not adequately considered or analysed. Most CBLRR measures promoted one-off risk assessment, formation of disaster management committees, awareness raising, and some predetermined structural (e.g., gabion boxes) or bioengineering measures. Such approaches resemble the practices of socio-politically neutral problematization based on technical solutions available within the supporting agencies (Coles & Quintero-Angel, 2018; Li, 2007). Such measures were often cited as successful in project evaluation reports (Zwi et al., 2013). However, my systematic literature review highlighted the continuation of such measures beyond the project end as a key challenge to CBLRR. This echoes the recurrent issues around sustaining community ownership and empowerment in CBLRR (Cooke & Kothari, 2001; Oven et al., 2017).

The review also highlighted about the limited number of publications on CBLRR in low- to middle-income countries. Likewise, most lead authors of those studies were from the high or very high-income countries. It is clearly necessary to conduct more research and to invest more in CBLRR sector in low- and middle-income countries. As Gaillard (2022a) emphasizes, there is a need for increased efforts in identifying and dismantling the barriers hindering local or grassroots researchers from coming forward. Only then the alternative epistemologies gain a voice and recognition (Cadag, 2022). The participatory landslide monitoring component of this study, elaborated in Chapters 6 and 7, exemplifies the benefits and potentials inherent in synergizing knowledge and expertise of local communities and academic researchers in co-producing shared knowledge and understandings for DRR.

8.2.2 Reflections on the context, culture, and local knowledge for landslide risk reduction: coalescence of hope and frustrations

The ethnographic research described in Chapter 5 was conducted with the goal of better understanding the context and underlying factors contributing to landslide vulnerability in Mathillo Sigarche. It sought to explore forms of knowledge and strategies employed by people to reduce landslide risk. Chapter 5 clearly identifies that the landslide vulnerability of people in Mathillo Sigarche has its roots in state-led historical marginalization and resource extraction. For more than 250 years, marginalized groups such as the Tamang were systematically exploited and disenfranchised, leaving them to often live on the least fertile land (Ghale, 2015; Mahat et al., 1986; Tamang, 1992). Consequently, a considerable proportion of Mathillo Sigarche's residents are essentially landless, as the ultimate land ownership often lies with the descendants of merchant families. Their ancestors had taken loans from merchants to manage economic hardships that had been exacerbated by excessive state taxes and forced labour. Conditions were often compounded by periods of disease, harsh environmental conditions such as drought or heavy rainfall impacting agricultural yields, and socio-cultural obligations to perform rituals such as marriage and *ghewa* (death ritual) for family members. When ancestors failed to repay debts that were often linked with high interest rates, or debt manipulation, they lost their land ownership to moneylenders. Detailed accounts of comparable narratives, depicting socio-economically disadvantaged groups or families losing their land to merchants or moneylenders, are explored in detail by scholars such as Caplan (1970) and Rankin (2004), amongst others.

In the recent years, the 2015 Gorkha earthquake and the escalating trend of state-sponsored haphazard development, such as poorly engineered rural roads, have led to an increase in landslide incidences in my study area. To make the situation worse, climate change is amplifying landslide frequency, nature and impacts across the Himalaya (Eyler et al., 2022) and is felt across Nepal's hill districts (Adhikari & Tian, 2021; Kincey et al., 2021; McAdoo et al., 2018; Petley et al., 2007). With government at all three tiers -local, provincial and federal- determined to expand the road density (NPC, 2017), the construction of rural roads—informally referred to as '*dozer roads*'—is likely to continue across the country (Pradhan, 2021; Sudmeier-Rieux et al., 2019), with the aim to improve access to health care, education, and income generation opportunities for the people living in the rural locations (Bhandari et al., 2012). This underscores the necessity to urgently shift from current haphazard road construction towards more systematic risk-sensitive practices (Lennartz, 2013). Put simply, DRR and broader development priorities must be more closely intertwined (Wisner et al., 2004) or otherwise, rural roads will continue to exacerbate challenges for socio-politically disadvantaged people due to the recurrent impacts caused by their consequent landslides.

Chapter 5 also explored how small- and medium-scale landslides, frequently experienced by many marginalized communities, can cause occasional injuries and deaths in addition to significant chronic and cumulative economic and psycho-social losses for people (Gaillard, 2022a; Shrestha & Gaillard, 2013). Despite this, such small and medium-scale disasters often remain invisible to politicians, public institutions, media, scientists, and civil society organizations, perpetuating a form of 'slow violence' (Davies, 2022; Davis et al., 2021; Nixon, 2011) or 'strategic ignorance' (Mcgoey, 2012).

8.2.2.1 Richness of local knowledge and strategies for landslide risk reduction in Mathillo Sigarche

This research also identified a rich pool of local strategies used by the Tamang people to live with landslide risks. Here, I summarize these strategies.

My ethnographic study illustrated that residents tend to be closely attuned to changes in or around their localities, particularly in areas they closely interact with on a regular basis (Johnson et al., 1982). Such smaller scales of change are typically hard to be identified in satellite imagery (Williams et al., 2018). However, local people's close connection with the landscape helps them identify and potentially anticipate the early signs or probable triggers of landslides such as scars on terraces, bulging of terrace walls, and the blockage of drainage channels. Local inhabitants also routinely reinforce terrace walls using stone masonry, allow trees to grow on terrace walls with routine pruning and thinning (see Figure 8.1), and ensure management of excess run-off from terraces through channel systems. In addition, responses are dynamic when, for example, at times of elevation of landslide risk, people either switch to less water intensive crops such as maize and millet or decide to temporarily abandon cultivation to allow the land to stabilize. If houses are at risk, people stay temporarily in makeshift shelters during the monsoon to reduce their exposure.

Figure 8.1: Trees grown on the terrace walls and edge of terraces

Other notable conditions people mentioned as important were faith-based. These included following moral behaviours and practicing offerings to territorial and clan deities, and territorial spirits. Local religious figures such as *Bombos* and *Lamas* were found crucial in providing guidance and leadership in performing such *Pujas* (worships/rituals). However, such beliefs did not necessarily exist in complete detachment from non-religious interpretations (Pigg, 1996). The simultaneous interplay of supernatural and more natural explanations of landslide risks and strategies to landslide risk reduction resonates with findings from other studies, including those by Klimeš et al. (2015), Bjønness (1986), Oven (2009), and Gergan (2017), illustrating the co-existence of religious and non-religious epistemologies. As observed by Pigg (1996) in the context of shamanism and modern medicine in rural Nepal and echoed by Chakraborty & Sherpa (2021) in the context of climate change in the Himalayas, many local people concurrently accepted pluralistic interpretations and actions in relation to landslide risks and risk reduction.

In addition, other socio-cultural factors such as reciprocity, shared experience of past landslides, experiential knowledge transmitted from the ancestors, 'everyday' priorities, and access to resources were found crucial in shaping local knowledge and actions (Cannon, 2015; Hewitt, 2011; IFRC, 2014; Oven & Rigg, 2015). Local people also emphasized that despite the diminishing community spirit attributed to monetarization of local economies and divisions based on political ideologies, the community ties revive during times of disaster. People also accentuated the centrality of the kinship and reciprocal assistance (Campbell, 1994) during evacuations, search and rescue, and psychological recovery of the people affected by disasters (Chase & Sapkota, 2017). Echoing what Rautela (2017) had emphasized in the context of 2013 Uttarakhand disaster in India, the local people of my study area underscored that the local community and fellow survivors serve as the first responders during disasters due to the delays in state-managed search and rescue efforts attributable to inefficient government mechanisms, adverse weather conditions and disruption of access to affected areas. Such community-led initiatives are often hailed as manifestations of their resilience capacities (Brown, 2014). However, as Tamang (2015) argues, an excessive romance with people's resilience may divert the necessary attention away from government's inefficiencies and the lack of accountability towards its citizens.

8.2.2.2 Limitations of local knowledges and challenges to their continuation

There's no doubt that the wealth of knowledge available amongst the people of Mathillo Sigarche has greatly reduced the risks and impacts of landslides and has assisted in attaining livelihoods through harsh conditions. However, such knowledges in general do not address historical power imbalances and the underlying root causes of vulnerability (Corburn, 2003). Local knowledges were generally tacit in nature (Mercer, 2012) and closely embedded in daily life and livelihoods (Hilhorst et al., 2015). This often made indigenous knowledge difficult to be recognized by 'outsiders', including myself, at first glance (Dekens, 2007). Although I tried to immerse myself in everyday life during my ethnographic study, I was inevitably unsuccessful in uncovering many other potentially relevant dimensions of local knowledge, beyond those presented in Chapter 5.

Some other limitations of and challenges to local knowledge have also been identified in my research. Many local people reported that they are less confident or aware of the progression of landslide precursors, that can at times be hard to recognise or even observe. Such unfamiliarity might result in both under- or over-estimation of risks (Mol et al., 2020), which can influence responses (Rollason et al., 2018). Similar to Basyal (2021)'s findings from his study conducted in the nearby Upper Bhotekoshi Valley, the people of Mathillo Sigarche used important dates and events such as the monsoon following 2015 earthquake *(Bhukampa gayeko saalko barkha),* the day when the Jambu landslide occurred *(Jambu maa pahiro gayeko din),* the time before the start of the multi-party democracy *(bahudal agadi),* a year after the election *(Chunab paxi ko barsa),* and when a son reached three years old *(chhora 3 barsa jati huda)* to provide reference to the occurrence of previous landslides[56]. While local inhabitants seem to have a good memory of dates and impacts of past landslides, perceptions of antecedent rainfall and soil moisture characteristics were inconsistent.

As I have shown in Chapter 5, local knowledges and strategies around landslide risk reduction and management are at risk of being lost in Mathillo Sigarche. While the evolution of these knowledges is inevitable, especially when there is change in community need and context (Agrawal, 1995), the decline in local knowledge is happening without better alternative. Like many other rural villages of Nepal, my study area is also facing the extensive outmigration (Childs et al., 2017). By moving to Malaysia and the Gulf for foreign employment, the local youths aspire to escape the intergenerational poverty 'traps' (Bird & Higgins, 2011). Although I have not investigated in depth the longer-term implications of outmigration in tackling chronic poverty, local people routinely cited outmigration as being the cause for an increased workload on women, children, and elderly who stay behind. Many also lamented that the intergenerational transfer of hazard histories and skills for terrace and drainage management, and routine performance of ritual offerings to territorial deities, all of which hold a crucial importance in landslide risk reduction, are being gradually eroded.

The detachment from agriculture and indigenous ways of managing landslide risks went hand in hand with an increased frequency of landslides in the study area, coupled with socio-ecological problems causing a decline in agricultural production. People considered that landslide frequency had increased due to the 2015 Gorkha earthquake and extensive rural

[56] Words in *Italic* font enclosed within parentheses in this sentence are the Romanized Nepali words for the corresponding terms.

road construction since. For a considerable proportion of people, particularly the elders and ritual practitioners like *Bombos* and *Lamas,* the increase in immoral behaviour and decline in indigenous practice such as traditional drainage management and periodic ritualistic offerings to territorial deities, had also caused the increase in landslide frequency. As also found out by Tennakoon et al. (2021) in the context of Aotearoa-New Zealand, the repetitive losses experienced by poverty-stricken people of Mathillo Sigarche had exhausted their capacity and willingness to further invest in restoring the affected land. Additionally, people were affected by the recurrent crop losses caused by frequent encroachment by wild animals, rendering agriculture an even less viable livelihood. The surge in both the frequency and severity of wildlife incursions in the recent years served as an added reason of demotivation for investing time, labour, and resources into farming, creating conditions for further wildlife related problems (Ghimire & Chalise, 2018; Koirala et al., 2021):

"*Protecting crops from wild animals has become near impossible. We somehow patrol maize from monkeys during day but can hardly do anything to porcupines that appear and destroy crops at night. We (Tamang) are born to suffer.*" (Buddhi Tamang, Male, 47 years, Personal Conversation, 2022)

Rautela (2015, 2020) cautions that the separation from agriculture further increases landslide risk by impeding the opportunities for the early identification and treatment of landslides. When people are detached from agriculture, little attention is paid to the routine maintenance of terraces and the reinforcement of terrace walls thereby promoting further landslide development (ibid). Thus, outmigration is not only the impacts of landslides, as commonly depicted in literature, but also can be the catalyst for triggering or escalating future landslide events (Cieslik et al., 2019). Put differently, a positive feedback loop was observed between landslides and outmigration (Jolivet, 2015; Lee & Kwon, 2022). At the start of my research, I had not imagined that people would be willing to leave the place where their livelihoods and culture are so deeply rooted (Sherry et al., 2018). However, a surprising finding for me was an apparently waning place attachment. To my surprise, many of the people repetitively affected by road-triggered landslides were ready to move to other areas if the state or other civil society organizations provided the opportunity:

"We would have moved to other places if we had alternatives. Regardless of potential danger, we can do little. We have no choices. We are compelled to remain here...." (Surya Lama, Male Respondent, 51 years, Personal Interaction, 2021)

8.2.2.3 Questioning bureaucratic mechanisms for landslide risk reduction: reflections from the field

Nepal's new constitution promulgated in 2015 (Nepal's Constitution, 2015), disaster risk management cycle focused DRRM Act 2017 (Disaster Risk Reduction and Management Act, 2017) and Local Government Operation Act (Local Government Operation Act, 2017) are widely acclaimed and heralded as a paradigm shift in enabling people's access to resources and decision making and improving DRRM efforts in Nepal (MoHA, 2018c; Nepal et al., 2018). The constitution and relevant legal frameworks affirm the DRRM as being the concurrent responsibility of local, provincial, and federal governments, with a primary authority and accountability assigned to the local governments in mitigating and managing small to moderate disaster events (IOM, 2020; Oxford Policy Management, 2020).

However, at Mathillo Sigarche, the Tamang community hardly experience the state's any presence in mitigating small- and medium-scale landslides that repetitively trouble them. The government's weather advisories were inaccessible, and even though I showed them examples, they considered the advisories to be vague and lacking useful details. Programs of geo-hazards risk assessment and corresponding relocation grants for high-risk households were limited to a few settlements in the district, with Mathillo Sigarche assessed only once since the 2015 Gorkha earthquake. My conversations with local authorities and NGO representatives who were involved in facilitating the assessment process highlighted that the delays and limited geographical coverage were tied with the lack of technical human resources at local levels, necessitating reliance on the NDRRMA[57] for the technical expertise. This scenario parallels with what Khatri et al. (2022) have highlighted in the context of climate change adaptation, illustrating when the decentralization of authority is mismatched with

[57] A nodal agency for Disaster Risk Reduction at Federal Level.

resource, capacity and accountability mechanisms at local level, it will not produce effective outcomes.

Local people mentioned that their requests for resources for landslide control measures were consistently ignored by the local representatives. Neither were the demands for compensating land and crops damaged by state-sponsored poorly engineered road construction addressed. Instead, they were met with the false promises to wait for the next local budgetary planning round or suggested to approach higher authorities at the district or province levels. Approaching higher authorities was not regarded practical or effective, particularly when an individual or community did not have good often personal connections. Furthermore, the additional expenses and time required to travel to the district headquarters to meet the higher authorities discouraged people to pursue this:

"We approached ward and Municipality offices seeking assistance and compensation regarding these landslides… They returned us empty handed by shouting like tigers and lions on us." (Surya Lama, Male Respondent, 51 years, Personal Interaction, 2021)

The above quote illustrates that the marginalized groups are not voiceless. Instead, they are not listened to, or their voice is hardly considered important by those in power (Gaillard, 2022a; Huber et al., 2017). It's not that the local government does not allocate budget for DRRM, the sums allocated are small. Greater budgetary emphasis is given to infrastructure development. For instance, less than 1% of the total municipality budget was allocated to DRR in FY 2021/22 (Barhabise Municipality, 2021). Negligible money then trickles down for pre-disaster risk reduction, while a larger proportion is spent either on clearing rural roads as well as the highway connecting to the Nepal-China border after a landslide (see Figure 8.2), or on ad-hoc post-disaster[58] relief distribution when there are human casualties/injuries and/or damage to houses. This tendency mirrors the conventional response-focused attitude of local authorities. Even when crops and agricultural lands are repetitively damaged by landslides, often triggered by government funded poor-quality road construction, people rarely received

[58] For all sorts of disasters occurring within the municipality including landslides, fire, floods and lightning.

relief or compensation. These circumstances are deepening a feeling of being neglected amongst local people by the state institutions.

Figure 8.2: A glimpse of situation of access road in Barhabise Municipality during monsoon

Another prominent issue that surfaced during my interactions with elected representatives and public authorities[59] is the growing tendency to attribute losses caused by hydro-meteorological hazards to *unfortunate heavy rainfall*, including climate change (Chakraborty & Sherpa, 2021). Equally, the overlapping roles in DRR for multiple levels and agencies were obviously being used to side-step blame (Maes et al., 2018). What is of concern is that such narratives from the socio-political elites divert the attention away from the many pertinent issues and challenges of socio-economically marginalized people like the Tamang, resulting in a situation that Corbridge et al. (2005) considered 'the relative scarcity of the state' in issues of public need or concern (p. 34).

[59] Conversation spans the representatives and authorities outside my primary research site too whom I met in different workshops and seminars.

My research has also shown how the volunteer community and household-level engagement in pre-monsoon drainage clearance, trail maintenance and ensuring safe disposal of surface runoff from fields are now almost extinct. Such activities were traditionally coordinated by a *Choho*—the village leader in Tamang's customary governance system (Parajuli et al., 2019). However, a series of political transformations in Nepal particularly since the 1951, such as the end of autocratic Rana regime, beginning of party-less Panchayat regime and multi-party democracy (Rankin et al., 2018; Shneiderman et al., 2016; Tamang, 2008), has undermined the importance of *chohos* in Tamang society. Consequently, in Mathillo Sigarche, the *choho* system disappeared after the death of last *choho* during the initial years of multi-party democracy in the 1990s in Nepal. According to the local inhabitants, the absence of the *choho* not only has impacted the people's engagement in communal activities necessary for reducing landslide risks, but also caused a leadership vacuum in mediating community issues with the political elites. This shows how the state policies and approaches can discard the traditional customary practices and be a cause of further vulnerability of marginalized groups (Parajuli et al., 2019).

Overall, despite apparently progressive politico-administrative transformations in the DRR sector, these changes are doing little to address the poverty and vulnerability of historically marginalized groups like Tamang. Government planning and resource allocation continue to overlook the Tamang people and their concerns (Lama, 2022). Such neglect serves to reinforce the concept of 'Tamsaling' amongst a broader spectrum of Tamang activists and political factions[60] (Tamang, 2009). While the indigenous knowledge and practices have contributed to survive thus far, people's capacity to cope with landslides is constantly squeezed due to compounding problems including: 'everyday' livelihood concerns (IFRC, 2014; Oven, 2009); the increased landslide incidences after 2015 Gorkha earthquake (Rosser et al., 2021); a changing hazard contexts (Oven et al., 2021); the diminishing mutual assistance and increased monetarization (Hilhorst et al., 2015); the outmigration of young people (Adhikari & Hobley, 2015); and the continued poor access to resources and decision-making processes (Lama, 2022).

[60] 'Tamsaling' refers to Tamang ancestral territory.

8.2.3 Reflections from participatory landslide monitoring: co-producing new ways of landslide risk monitoring for landslide risk reduction

Participatory landslide monitoring (Chapters 6 and 7) delved into how landslide knowledge specific to the local context could be co-produced by carefully executed participatory action-oriented research. By partnering with the local people, the research showed that participatory landslide monitoring combining local knowledge and scientific instrumentation could serve as a promising method for enhancing understanding, advocacy, and risk reduction efforts. Through collaboration with local people and stakeholders, the research identified the information deemed important and useful for exploration through landslide monitoring efforts. This included selecting sites of community concern for monitoring and framing the goals of monitoring and data analysis to address the interests and concerns of people.

For instance, use of acoustic emission sensors in landslide monitoring enabled to answer people's concerns regarding slope stability conditions. Understanding the relatively stable status of the monitored slopes during the monitored period, the participatory monitoring was useful to reduce anxiety surrounding potential landslide risks. Furthermore, the monitoring efforts also showed potential to bring clarity and some element of uniformity in people's understandings about the rainfall distribution and characteristics, and its potential relationship with slope deformation, which may assist in future advocacy.

This action-based research on landslide monitoring was preceded by eleven months of on-site ethnographic engagement. The ethnographic study was useful in understanding the local context and power dynamics, and was valuable for identifying potential collaborators and averting 'elite capture' (Nadiruzzaman & Wrathall, 2015). Such engagement was crucial for understanding the limitations of local knowledges despite the rich and diverse understandings possessed by the local inhabitants of their landscape, the landslide hazards and potential landslide risk reduction measures.

Several gaps were identified during this process, which guided our participatory landslide monitoring efforts. These included the limited understanding of the dynamic susceptibility of landslides happening in areas beyond eyesight or regular interaction, difficulties in monitoring risks during nighttime and/or heavy rainfall, limited understanding of the sub-surface, nonuniform perceptions amongst people about rainfall during previous landslides, and a limited ability to tell with confidence if a certain slope is stable or potentially active. Beside these, people did not consider government forecasts and weather advisories useful. Similarly, local authorities repeatedly mentioned that they lacked a low-cost measure that could be potentially used for monitoring or reducing landslide risks.

With background understanding of these gaps, which encompassed both local and some institutional knowledge, participatory landslide monitoring was conducted at two slopes identified and prioritized in a participatory manner involving inputs from local people, local stakeholders and 'experts.' Here, I use the term 'experts' to principally suggest my research supervisors and other researchers involving geologists, geographers and geotechnical engineers from Tribhuvan University and NSET-Nepal involved with the Sajag-Nepal project (https://www.sajag-nepal.org/). Sajag-Nepal project is a UK Government's Global Challenges Research Fund (GCRF) funded research project that aims to improve preparedness on multi-hazards in Nepal. Some of my research supervisors from Durham and Northumbria Universities in the UK, and Nepal's Tribhuvan University are key personnel in the research. There are overlaps between some components of my research and the Sajag-Nepal project, particularly related to the landslide monitoring aspect. This provided me an opportunity to exchange expertise and knowledge as necessary.

Recognizing the influential role of ritual specialists in the 'everyday' lives of people of Mathillo Sigarche, local *Bombo* and *Lama* were actively involved in the participatory landslide monitoring alongside other community members. Local people relied on and trusted them for healing illness or seeking guidance on performing religious and ceremonial practices. As a result, their involvement proved crucial in fostering collaboration with other people in the community. Additionally, their frequent interactions with many people facilitated the quicker and wider dissemination of information about research activities and progress to the broader community members. Similarly, at Tallo Sigarche, given that the proposed site was in the school premises, the schoolteachers, members of the school management committee and some residents living in the area close to the monitoring site were involved.

Throughout the research, the participatory landslide monitoring efforts greatly benefitted from the wealth of expertise of the local people. As mentioned elsewhere in this thesis, their input was crucial in shortlisting and finalizing sites for monitoring and in determining what information from the monitoring would be of wider benefit. Their role in disseminating the research objectives and findings amongst family, neighbours and networks was valuable in reaching a wider audience. Their insight and inputs were crucial in installing and repairing the equipment. Likewise, their observational information was vital in cross-validating the instrumental data.

8.2.3.1 Participatory landslide monitoring for landslide monitoring and risk reduction

The analysis of yearlong dataset of monitored parameters indicated that the sites are fairly stable providing some relief to the local residents. The data has also provided some useful insights into the annual, seasonal, and daily patterns of rainfall, soil moisture and acoustic signals. The higher values of rainfall, soil moisture and acoustic emission during monsoon matched with the local perception about the seasonality of rainfall and landslide risks. The nature of the rainfall patterns was shared with people in the form of Youtube video developed using Nepali language in texts and narration (Shrestha, 2023). The access to video was provided to the users having video links only. The video was viewed more than 200 times by December 2023 after its upload in June 2023.

Youtube platform was chosen because the research participants suggested this as a useful means to reach certain research collaborators and broader audiences, unable to participate the in-person preliminary findings sharing meetings held in June 2023 due to the overlaps with their agricultural priorities. Though I have not systematically assessed the effectiveness of the video in creating the intended impact (Shaikh et al., 2023), the response I received during my occasional virtual catchups and final face-to-face sharing meetings with local people conducted in March 2024 have been encouraging. The rainfall, soil moisture and acoustic emission data (as discussed in Chapter 7) were found to be useful in bringing about more agreement about rainfall, soil moisture and slope deformation characteristics.

The precipitation data analysis showed that rainfall during monsoon is not evenly distributed. Put simply, some days can have higher rainfall whereas the other days can have significantly less making it difficult to generalize patterns. Likewise, the rainfall within a 24-hour period tends to occur over short periods, rather than evenly throughout the day. The evaluation of the time-lags between the rainfall and soil moisture during the monsoon showed the longer lag at 110 cm depth as compared to the near surface highlighting the potential role of infiltration in controlling delayed responses to precipitation.

In this research, although the acoustic emission data did not signal any indication of alarming slope instability, it did demonstrate an ability to capture even very small deformations continuously at a very high temporal resolution[61] (Uhlemann et al., 2016). This indicates the effectiveness and potential to address many of the gaps and limitations of site-specific landslide monitoring systems outlined in Chapter 6, including around the limited availability of low-cost tools to continuously monitor landslide precursors (Dixon et al., 2018). Hence, a key benefit of landslide monitoring used here could be the improvement in ability to monitor and predict landslides with high temporal and spatial accuracy. This is significant in the context where most of us understand about the increased landslide risks during the rainy season, particularly during periods of heavy rainfall, but it remains difficult to say with confidence the timing and location of any individual landslide (Zhao et al., 2019). Information on the location, status and rates of slope instability helped to lessen the community anxieties, and was perceived by research participants to empower them in taking informed decisions around preparedness, evacuation, (temporary) relocation, or advocacy with local stakeholders for risk reduction and mitigation measures (Dixon et al., 2022; Liu et al., 2016; Malakar, 2014).

As underscored by Wolff (2021) in the context of community-based flood risk monitoring, my own research realized the benefits of participatory research extended beyond the primary research focus. The collaboration meetings were found useful to initiate discussion and reflection about other landslide and 'everyday' issues too. During the research, alongside topics related to landslide monitoring, the local research collaborators actively engaged in discussing other issues such as the increased landslide risks and impacts due to poorly engineered road construction, challenges faced while residing in temporary makeshift shelters during the monsoon, and other pressing issues related to wild animals damaging crops and the outbreak of lumpy skin disease in their cattle. For some issues, people actively approached the local government and civil society organizations. At Mathillo Sigarche, two examples of

[61] 15 min sampling intervals were set for my study.

their successful advocacy were prompting a pause in the decision of constructing alternate alignment of the road through the slope where the participatory landslide monitoring was undertaken and securing some resources for buying tarpaulins to be used in as temporary shelters during the monsoon. The icing on the cake is that these successes have increased morale via gaining a voice through continued collective efforts:

"The poor should not be constantly cornered. Survival had been always tough for us. Now, the floods and landslides add to our hardships. We must keep on doing something." (Bire Tamang, Male, 70 years, Personal Conversation, 2023)

Overall, our participatory landslide monitoring efforts using rainfall, soil moisture and acoustic emission sensors demonstrate the potential and benefits of bringing together the knowledge and perspectives of 'certified' and 'uncertified' experts in creating new and shared knowledge on landslide monitoring and risk reduction.

8.2.3.2 Challenges of participatory landslide monitoring: reflections from the field

As with all participatory processes, the opportunities and potential of participatory landslide monitoring cannot be taken for granted (Gaillard et al., 2016). Our participatory landslide monitoring work also encountered challenges.

First, this research was regularly affected by the absence of key individuals, particularly related to the seasonal migration to nearby quarrying sites and longer duration of overseas migration to Malaysia and Gulf countries for employment. A Facebook status message in Nepali language from an active local research collaborator at the time of flying for labour migration to Malaysia exemplifies the aspiration of poor and marginalized individuals by migrating abroad:

"*5 hazar ko passport ani karodau ko sapana bokera jadai chhu aja"* meaning *"I am flying with the passport worth 5000 (NRs.) and dreams worth tens of millions*[62]*"* in English. (Nabin Tamang, Facebook status, 16th January, 2023)

[62] 1 USD = ~130 NRs.

For space constraints, I have only scratched a surface of the intricate relationship between migration and disaster vulnerability in this thesis. Readers interested in delving deeper can explore works by researchers such as Rigg & Oven (2015), Rigg et al. (2016) and Cieslik et al. (2019), among others.

Even with those staying behind, accessing time and active engagement needed careful coordination, planning and flexibility, particularly during cropping, weeding and harvest seasons. There were also occasional opportunities for people to work in state-funded development project, such as rubble/stone soling—the process of hand packing stones on roads (see Figure 8.3), or construction of public infrastructure within or in nearby villages. In cases when participants were absent, I tried to bridge the gap by updating them by phone afterwards, and by revising the discussion points in the successive meetings.

Figure 8.3: Local inhabitants of Tallo Sigarche busy hand-packing stones over a surface (Photo taken in March 2023)

Second, this research was also partly affected by the technical issues encountered with the weather and soil moisture sensors. These ranged from mobile network issues to occasional failure or malfunctioning of the sensors, both hindering the data collection and communication. This emphasizes the risk of sole reliance on technocratic solutions and reinforces the importance of hybridized methods encompassing both automated and manual observations (Intrieri et al., 2012). Future research could consider having multiple means of data transmission and storage (for example provisions for using multiple sim-cards and mobile phone networks) to decrease the chances of data loss or gaps due to network issues (Michoud et al., 2013). Allocation of additional resource and time for regular equipment inspection, maintenance and replacements should also be carefully considered (Baczynski & Bar, 2017).

Third, this research faced some practical challenges during the installation of acoustic emission sensor at research sites. A lighter drilling machine that had worked for drilling at Tallo Sigarche with predominantly silty sand broke while drilling through the boulders at Mathillo Sigarche. This exemplifies the need of robust machine for all sites. The drilling stalled for several days and was only completed when a more powerful drilling machine was available. Transporting the extremely heavy components of the drilling machine[63] required construction of a temporary access path through the terraces and involved many local people to help move the equipment. For future similar work, careful planning for selecting sites and addressing such practical challenges are recommended. Additionally, it's also important to prioritize planning for provisioning continuous water supply and site fall prevention strategies when operating the drilling machine.

Fourth, although the nature of the research was repeatedly shared on multiple occasions, there was an expectation raised that I might be able to link the community to NGOs or donor agencies. This particularly occurred when there was an increased visibility of research contributors from the Sajag-Nepal project, before and during the installation of the slope monitoring instruments. These raised expectations were tempered by repeated iteration of the research scope and limitations. Furthermore, the local research collaborators did not limit themselves to aspects of landslide monitoring, but proactively discussed other issues and approached local representatives, NGOs, and social workers. Consequently, they were able to draw some resources for setting-up seasonal temporary shelters. Future analogous research should regularly iterate the research objectives and limitations to manage community

[63] An engine of the drilling machine was approximately 80 kgs.

expectations. While being aware that we, as researchers, also have limitations and hence, we cannot provide solutions to every local problem or concern. However, where practical, the researcher should act as the facilitator to link the community with existing public, private and civil society organizations for addressing their pertinent issues.

Finally, I had to regularly explain the difference between landslide monitoring work that I was conducting, and EWS. Most people including government authorities described landslide monitoring synonymously with EWS. However, beyond landslide monitoring using rainfall, soil moisture and acoustic emission sensors to better understand the dynamic behaviour of slope in response to differential rainfall and soil moisture conditions, my research did not involve with the other vital components of a landslide EWS, such as a warning model, or system of response (Calvello, 2017). This was something I had to regularly clarify during my project.

8.2.4 Broader reflections

Over more than five decades, scholarly discourse has underscored the importance of considering deep-rooted vulnerabilities and giving greater attention to local knowledge and capacities for achieving better outcomes in DRR (Faas, 2016b; Oliver-Smith, 2016). However, the prevailing approach in the DRR practice continues to be dominated by Hazard-Centric Approaches (HCAs). Drawing on the insights derived from my retrospective review (Chapter 4), the ethnographic study conducted in the study areas through immersive fieldwork and ethnographic semi-structured interviews with DRR practitioners and authorities (Chapters 5 and 6), as well as nearly a decade of prior practical experience of working with different INGOs and the Red Cross as a DRR practitioner, here I aim to reflect on DRR research, policy, and practice.

The risk equation [for example, Disaster Risk = Hazard x (Vulnerability/Capacity - Mitigation)] articulated by Wisner et al. (2004) and elaborated upon by Wisner et al. (2012), which plays a significant role in informing DRR policies and practice from global to local levels, is widely embraced by DRR professionals in Nepal as a part of their awareness raising and capacity-building initiatives. Gaillard (2022a) contends that this conceptualization of disaster risk has reinforced rather than bridged the dichotomy between nature/hazard and culture/vulnerability, leading to the proliferation of polarised perspectives, policies, and practice. Along the same lines, this study also revealed that DRR institutions predominantly endorse normative and standardized behaviours, alongside top-down technocratic solutions to mitigate 'extra-ordinary' hazard events (Gaillard, 2022a). Greater institutional resources and attention are allocated to post-disaster response and reconstruction (Oliver-Smith, 2016). This underscores a predominant emphasis placed on response-centric and HCAs to DRR in practical implementation and exposes a discrepancy between the theoretical promises and tangible achievements in the sector (Gaillard, 2022a).

Typically, HCAs promote technocratic solutions primarily aimed at anticipating and mitigating hazards (Gaillard, 2019; Oven et al., 2019), often overlooking the underlying socio-cultural and political processes that perpetuate uneven disaster vulnerabilities and impacts (Faas, 2016b; O'Keefe et al., 1976; Wisner et al., 2004). Moreover, HCAs tend to prioritize severe yet infrequent events, thereby neglecting the 'everyday' challenges and frequently occurring small-scale events, alongside the significant material and psychological repercussions that smaller events can cumulatively entail (Cadag et al., 2017; Gaillard, 2022b). Consequently, many individuals and families residing in places prone to frequent small-scale disasters, such as the landslides considered in this study, are often left to confront these hazards on their own without support or resources.

As encountered in this research, official records frequently overlook small-scale disasters, particularly when they cause no human casualties. As mentioned in Chapter 5 (Section 5.3.2.1), at least three past incidences of landslides that caused injuries and damage to household property, but no or less than five human deaths, were missing from the government's database. Such incomplete inventories can then significantly distort the analysis of disaster trends and hotspots, as well as impact upon decision-making regarding resource allocation for risk reduction research, policy initiatives and practice (Rautela, 2016). Additionally, as highlighted in Section 8.2.2.3 and elsewhere, this study identifies that the requests from local inhabitants to address landslide-related concerns are consistently disregarded by the local and district authorities, with requests lost or unaddressed within the complexity and ambiguity of the various levels of DRR governance (Maes et al., 2018, 2019; Vij et al., 2020).

My study also highlighted that even the approaches claiming to centre on vulnerability reduction that run alongside a recent surge in resilience-centred approaches, tend to narrowly concentrate on identifying and strategizing socio-politically 'neutralized' and standardized mitigation measures across different phases of the disaster management cycle, including: prevention, mitigation, preparedness, warning, relief, rehabilitation and/or reconstruction[64] (Cannon, 2015; Coetzee & Van Niekerk, 2012; Faas, 2016b; Gladfelter, 2018; Shah et al., 2023; Gaillard, 2022a). Such socio-politically 'neutralized' solutions promote technical solutions for hazard management that are politically easier to manage compared to restructuring socio-economic imbalances (Huber et al., 2017; Oven & Rigg, 2015). In prioritizing technical solutions, such approaches undermine the resource and power disparities within communities (Coles & Quintero-Angel, 2018), and consequently fail to address the consequences of historical resource dispossession and political marginalization that perpetuate such asymmetries (Cameron, 2012).

In Nepal, DRR organizations, especially NGOs, often employ Participatory Vulnerability Capacity Assessment (PVCA) tools, commonly facilitated by 'outsiders' who lack a nuanced understanding of the resource and power asymmetries within the community (Cooke & Kothari, 2001). The application of participatory tools can be guided by preconceived notions of the problem and solutions, resulting in a failure to understand the genuine priorities or to address the underlying causes of vulnerability within the community (Gaillard & Mercer, 2012; IFRC, 2014; Oven et al., 2017). In essence, such approaches overlook the complexities of how and why people are vulnerable (Cannon, 2008; Faas, 2016a; Oliver-Smith, 2016). Gaillard (2022a) characterizes such tendency as '*facipulation*', wherein the process prioritizes the interests of 'outsiders' over those of the community, leading to what IFRC (2014) describes as 'scratching where people don't have an itch!' (p. 68). 'Outsider' organizations, particularly NGOs, often enter communities with preconceived notions that local people are 'naïve' or 'ignorant' (Oven & Rigg, 2015). As a result, as indicated by key informants working with different NGOs and INGOs, a significant proportion of project resources are allocated and

[64] Different Disaster Risk Reduction organizations and professionals consider a four to seven-phased disaster management cycle (see, for examples, Baird et al., 1975; Neal, 1997).

spent for awareness raising programmes and top-down DRR sensitization and response trainings, often overlooking the valuable insights and efforts already present within the community.

This thesis also explored ideas around knowledge co-production as a potential means to realign the disconnect between participatory approaches and needs on the ground. In long-term wider academic research in Nepal on a range of topics, there has been substantial critique of the coercive nature of development and knowledge generation, and the shortcomings of the participatory approaches. For instance, in his book titled *"Living Between Juniper and Palm: Nature, Culture, and Power in the Himalayas",* Campbell (2013a) questions the emphasis placed on socio-culturally detached nature conservation endeavours such as the establishment of National Parks. He characterizes the emphasis given to creating 'enclaves of nature' under the guise of ecological conservation as a form of 'ecological scapegoating' of the rural poor, who are deeply connected with nature for subsistence and cultural identity, thereby exacerbating their marginality and concerns. He challenges the commonly held perception by conservation authorities that views the presence of local people as illegitimate and a threat to the nature conservation (ibid).

In another study, Campbell (2004) underscored the discrepancy between the interventions of development agencies and the socio-cultural context of communities in Nepal's Himalayan Rasuwa District. He highlighted how the interventions promoted by development actors, such as fruit production necessitating a continuous settled presence, sharply contradicted the transhumant agropastoral practices involving seasonal movement of livestock. Undermining of traditional practices deeply ingrained into the fabric of local lives and livelihoods consequently failed to yield the desired outcomes.

In a similar vein, Nightingale (2005) scrutinized the 'community forestry' sector in Nepal, often lauded as a model for participatory conservation. Her research uncovered how the sector undermines local knowledge and community needs regarding forest resources, favouring the rationale of 'scientific' or 'expert' knowledge. Nightingale highlighted that the 'community forestry' sector disproportionately benefits the local elites while distancing the poorest from institutional decision-making around forest management.

Likewise, Sherpa (2015) examined institutional climate change initiatives in Nepal's Mount Everest region to explore how such activities often treat local people merely as passive recipients of 'scientific' knowledge, disregarding their firsthand understandings of environmental change. Sherpa emphasized that while institutional efforts have increased local people's receptiveness to 'scientific' knowledge, they have also instilled fear of potential climate change impacts, and frustration over repetitive discussions without concrete actions for risk reduction. Sherpa's findings resonate my own experience, where I encountered similar frustrations among research participants who had experienced many researchers and employees of the government and non-government organizations who had never returned to their village after collecting data.

In separate studies, Yeh (2016) and Chakraborty & Sherpa (2021) advocate for a transition from 'expert-driven' approaches to 'knowledge co-production' approaches. Such emphasis to incorporating pluralistic knowledges is believed to result in a 'win-win' situation for both 'certified' and 'uncertified' experts. Such work now extends beyond environmental conservation and climate change adaptation (Lane et al., 2011; Wheeler & Root-Bernstein, 2020). Currently, there is a growing recognition of the value of knowledge integration in the field of DRR as well (Hadlos et al., 2022; Vasileiou et al., 2022).

In my research, I partnered with local collaborators to co-produce shared insights on landslide monitoring following repeated interactions—a key attribute of participatory action research (Kindon et al., 2007). While doing so, I adapted the insights from the 'Process Framework' originally formulated by Mercer et al. (2009, 2010) for DRR in Small Island Developing States, and subsequently revised by Kelman et al. (2009) for the context of climate change adaptation.

The framework proposed by Mercer and colleagues includes four steps for knowledge integration: 1) community engagement, 2) identification of vulnerability factors, 3) identification of indigenous and scientific strategies, and 4) development of integrated strategy (Kelman et al., 2009; Mercer et al., 2009, 2010). While Mercer et al. (2009, 2010) and Kelman et al. (2009) primarily employed the tools from the Hazard, Vulnerability and Capacity Analysis (HVCA) toolkits, I opted for ethnographic methods (Hammersley & Atkinson, 2019). Although the ethnographic approach requires more time and flexibility compared to the HVCA tools, I found the ethnographic methods beneficial in better understanding the internal power dynamics that may otherwise perpetuate 'elite capture' (Nadiruzzaman & Wrathall, 2015; Nightingale, 2005; Sovacool, 2018). I also found a greater ability to articulate the deeper socio-economic, political, and cultural contextual nuances, alongside the biophysical factors was enabled by this approach (Cannon, 2008; Wescoat Jr., 2015). Put differently, this helped in better understanding of the underlying causalities behind people's vulnerabilities, impacts of disasters, people's relational power and priorities, and risk reduction behaviours (Ayeb-Karlsson et al., 2019; Thomas et al., 2018; Yeh, 2016).

For instance, as underscored in Chapter 5, the ethnographic engagements yielded invaluable insights into the underlying causes of vulnerability of Tamang people. These included the systemic marginalization and exploitation of their resources, perpetuating the recurrent cycles of poverty, deprivation of formal education, food insecurity, and limited participation in administrative decision-making processes (Lama, 2022). The ethnographic approaches also shed light on various community issues and challenges, such as the loss of tenancy rights to moneylenders, the burden of high-interest loans, increased responsibilities on women, children and elderly due to male outmigration, the compounding effects of small but frequent landslides often overlooked by DRR agencies and authorities, and the shortage of agricultural workforce crucial for carrying out agricultural works having implication for landslide prevention and mitigation. Drawing from my background in DRR practice prior to my PhD along with the insights gained from the semi-structured interviews conducted with DRR practitioners during my research, I assert that uncovering such levels of breadth and depth of issues would not have been feasible within the constrained timeframe of employing HVCA tools.

Additionally, echoing the findings of Agrawal (1995), my ethnographic study revealed the inherent hybridization of local knowledge with scientific or 'external' knowledge. Through my fieldwork, I found that many local inhabitants attribute landslides to a combination of supernatural, natural, and anthropogenic factors. They believed in both religious and non-religious strategies to mitigate landslide occurrence. Understanding and knowledge acquisition therefore transcend place-based boundaries (Cameron, 2012), and instead, knowledge is dynamic and continually shaped through interactions with various people and institutions beyond the 'local' context (Cruikshank, 2014; Ojha et al., 2016). However, as underscored by Sherpa (2015), Yeh (2016) and many others, the local people have their own ways of observing and interpreting their environment, which may differ from the methods of 'certified' experts'. For example, as highlighted in Chapter 7, the local research participants gauged the past number of rainy days and characteristics of rainfall in monsoon based on their involvement in paddy plantation. This is different than the methods employed by 'certified' experts, who commonly evaluate these by using the scientific instrumentations or modelling. Additionally, Table 6.2, presented in Chapter 6, summarizes the strategies employed by the inhabitants of my study area, demonstrating striking parallels to what is deemed as 'certified' knowledge (Agrawal, 1995; Nygren, 1999; Ojha et al., 2016).

Regarding Mercer et al. (2010)'s framework for knowledge integration, although Mercer, Kelman and their collaborators acknowledge the importance of moving beyond the dichotomy between 'indigenous' and 'scientific' knowledges (Kelman et al., 2009; Mercer et al., 2009, 2010), the delineation of 'indigenous' and 'scientific' strategies in step 3 of their framework may inadvertently confuse without sufficient context. For example, Mercer et al. (2009) elaborated on their use of 'scientific' strategies on pages 158 and 169, clarifying 'scientific' as knowledge originating outside the community. Any attempts to compartmentalize knowledge risk reinforcing the hegemony of 'external' knowledge or more specifically a Eurocentric perspective, by deeming 'local' knowledges and strategies as being inadequate or illegible (Cameron, 2012; Gaillard, 2022a). This was reflected in my discussions with DRR practitioners working in Nepal. Although, national and international NGOs frequently assess local knowledges and strategies, the gathered information were often confined to documentation without adequate integration with 'certified' experts driven knowledge for DRR.

Conversely, due to the essentially implicit nature of most local knowledge and strategies (Mercer, 2012; Sanford et al., 2020), studying these knowledges is not a straightforward or easy task. The public nature of the HVCA process could also cause participants to hesitate in sharing knowledge (Mosse, 1995). Therefore, compared to the relatively brief HVCA process, the efficacy of the framework proposed by Mercer and her colleagues necessitates considerable time, effort, and engagement, particularly when facilitated by an 'outsider'. This is where use of ethnographic approaches could be indispensable.

In contexts such as my study areas, it is important to explore and elaborate the consequences of broader socio-economic and political transformations, such as migration and shifts in traditional livelihoods and labour (Ensor et al., 2019). These processes significantly influence intergenerational knowledge transfer, and perpetuation, modification, or abandonment of local strategies. Herein exists an opportunity to expand the scope of the Mercer et al. (2010)'s framework, through stepping back from an exclusively hazard-centric discussion and posing more open-ended questions around people's lives and livelihoods (Davis et al., 2021; Ensor et al., 2019). Similarly, as emphasized by the developers of the framework, the researcher/facilitator should collaborate with other researchers and stakeholders to identify the potential external strategies for risk reduction.

While the outputs of steps 1 to 3 of the Mercer et al. (2010)'s framework have been discussed in Chapters 5 and 6 of this thesis, step 4 informs Chapters 6 and 7. This step required adjustment to align with my research objectives. While Mercer and her colleagues focused on developing of integrated strategy for overall issues related to disaster vulnerability, I specifically focused on conducting participatory action-oriented research on landslide monitoring. This involved collaborative efforts to devise strategies to monitor landslide-prone slopes, delineate roles, establish criteria for analysing monitored parameters, install landslide monitoring instruments, and maintain the instruments. While I assumed the primary role in analysing the instrumental data, the inputs from local collaborators were pivotal. Their observational data was instrumental in triangulating data as well as in filling data gaps. Additionally, we also discussed and devised strategies to secure funding for wider community held, such as the procurement of tarpaulins for setting up temporary shelters for use during the monsoon.

In summary, I have found Mercer et al. (2009, 2010)'s framework along with the participatory action research approach followed in this research useful in integrating diverse forms of knowledge to enhance DRR. However, the effectiveness and success heavily rely on the facilitator's competency and commitment to accountability to the research participants (Chambers, 1994; Cooke & Kothari, 2001; Preuner et al., 2017). Drawing on my own experience, the deeper engagements in various steps of Mercer et al. (2010)'s framework yield better outputs. In addition, I propose the addition to the framework of a fifth step, tentatively labelled 'development and implementation of action plan'. This addition would help ensure that integrated strategies are grounded with well-defined roles, and clear plans with timelines for implementation, which is currently missing in the framework. I believe the inclusion of this proposed fifth step would inform the evaluation and revision of the strategies, as necessitated by the framework.

8.2.5 Major implications for policy and practice

The findings and conclusions from this study have multiple implications for local, national, and global policy and practice framework for sustainable disaster risk reduction and management. While these implications are primarily useful for the Nepali context, I consider these to be valid for other wider contexts having comparable issues and challenges.

8.2.5.1 Need for giving greater emphasis to addressing underlying causes of disaster vulnerability

This research clearly indicated that the landslide risks and impacts for marginalized groups like Tamangs have their roots in the state-led historical marginalization and resource extraction. Years of oppression has led the Tamang people to have limited access to resources and decision making. Despite growing calls at both global and national scale for wider recognition of the socio-cultural construction of risks and proactive risk reduction, this research demonstrated the negligible changes being felt at grassroots level. A significant proportion of the DRR budget is spent for post-disaster relief distribution, with some formulaic committee formation and emergency response training (Khatri et al., 2015). These limited efforts do little to reduce the vulnerability of people. On the contrary, the state's involvement in executing poorly planned development practices was found to be aggravating people's vulnerability. Paradoxically, the local authorities often pass the blame on abnormal rains or on other district, province or federal authorities for increased landslide incidences and their impacts. Consequently, a recurring cycle of poverty, food insecurity, and poor access to education and resources is magnifying the vulnerability of people.

Therefore, a key implication from this research is the call for a radical shift in disaster risk reduction and development practice that does justice to historically marginalized groups by addressing power inequalities, and unequal access to resources, wellbeing opportunities and decision-making processes (Cameron, 2012; Gladfelter, 2018; Shrestha & Gaillard, 2013).

8.2.5.2 Need for giving greater emphasis to small- and medium-scale disasters

The study findings indicate that the repetitive losses from frequent small to moderate disasters have devastating effects on the people's wellbeing and capacity to cope with future disasters (Bowman, 2022). However, most disaster risk reduction, response and recovery policies and plans are based on the consideration of large disasters, whereby small-scale disasters remain largely overlooked in research, policy and practice (Shrestha, 2016). As Gaillard (2022a) reflects, such approaches mirror the dominant 'western' ways of viewing and addressing the issues by establishing specific norms and standards which often overshadow the diverse concerns, priorities, and viewpoints of many marginalized populations, such as those in my study area. Hence, this research emphasizes the need to increase focus on small- and medium-scale disasters alongside the extreme disasters to get a fuller picture of disaster impacts and vulnerability. It is imperative to address the enduring effects of 'strategic ignorance' and 'slow violence,' stemming from the repetitive disregard of people's concerns and priorities regarding small- and medium-scale disasters (Davis et al., 2021; Mcgoey, 2012; Nixon, 2011).

The current emphasis on extreme but less frequent events in disaster research and DRR policies and planning risks impeding the achievement of global commitments and targets aimed at better understanding and reducing the disaster risks and impacts, as outlined in Sustainable Development Goals (UN General Assembly, 2015), Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015), and subsequent national policies and action plans of Nepal (MoHA, 2018a, 2018b) aligned with global priorities and frameworks. While the disaster database called the BIPAD portal (https://bipadportal.gov.np/) managed by NDRRMA in Nepal has started recording the smaller events in the disaster database, it lacks the disaggregated information. National and global disaster databases like this should be improved to incorporate the disaggregated data of the impacts of small- to medium-scale hazards that concern many marginalized people like Tamangs of my study area. Additionally, alternative methods of evidence generation, such as audio-visuals, elaborated writings and narratives should be prioritized to make sense of the situations and inform DRR policy and practice (Barclay et al., 2023; Gaillard, 2022a).

Promotion of three simple rules proposed by Milledge et al. (2019) can also be useful. Their rules suggest for avoiding steep channels with steep areas in the upslope; minimizing the angle to the skyline; and minimising the angle of slope under foot but not at the expense of increasing exposure to steep channels or the skyline angle. Furthermore, as my research has demonstrated, collaborating with local people to monitor the slopes of public concern using low-cost instruments, like those utilized in this research, could provide valuable insights for planning and implementing risk mitigation and reduction measures.

8.2.5.3 Need for giving greater emphasis to local knowledge and meaningful participation in institutional and community-based disaster risk reduction measures

Chapter 4 underscored that the community-based landslide risk reduction measures implemented elsewhere across the globe do not adequately collaborate with the local people and incorporate the local knowledge. Similarly, Chapter 5 highlighted that the institutional responses to landslide risks in Nepalese communities like Mathillo Sigarche are still top-down and response focused. Echoing the wider benefits of people's participation and incorporating local knowledge in DRR as highlighted in academic literature (see, for example, Dekens, 2007; Gaillard & Mercer, 2012; Lane et al., 2011; Vasileiou et al., 2022), this research (Chapters 5 and 6) illustrates how the local people possess and utilize a wealth of knowledge and expertise to cope and live with disaster risks. Furthermore, this research (Chapter 6 and 7) demonstrated how the meaningful participation of local people and integration of local knowledge in research improve identification and resolution of community problems and priorities (Chakraborty & Sherpa, 2021; Davis et al., 2021). In DRR, such approaches contribute to a better understanding of vulnerability contexts and can result in innovative and socially acceptable risk reduction measures. In essence, this research underscores the significance of exploring and incorporating the invaluable local knowledge and capabilities of vulnerable groups for understanding and addressing disaster risks and vulnerabilities.

8.3 Conclusions, limitations, and recommendations

This research critically assessed the socio-cultural institutions and processes influencing the local knowledge and strategies for landslide risk reduction using ethnographic approaches in a rural Tamang community located in Sindhupalchok District of Nepal. This study showed that combining political ecology and cultural insights in disaster risk reduction studies help us understand the role of historical power and resource asymmetries, and people's belief systems and values in shaping the differential disaster vulnerabilities, risk perception and risk reduction behaviour. Furthermore, carrying out the participatory landslide monitoring at two slopes, this thesis has also shown how the local and scientific knowledges can be blended to co-produce shared knowledge on landslide risks and risk reduction. This section will summarize the original contributions to knowledge made by this research, highlight research limitations, and recommend avenues for further research.

8.3.1 Key conclusions from the research

The key conclusions drawn from this research are summarised below:

1. This research highlights that the local people possess and utilize a wide range of knowledge and strategies to reduce the risks and impacts of landslides and recover from the effects. The beliefs around the natural, super-natural and anthropogenic causations of events, moral values and community cohesion, available resources and rational comparison of risks and opportunities were found influencing knowledge and strategies. The multiplicity of people's knowledge and strategies make them the active players capable of contributing to disaster risk reduction. Most of the local strategies are closely linked to and with the nature of people's agriculture-based livelihoods. This research also revealed that the younger generations are increasingly detached from agriculture due to the combined effects of outmigration and schooling. This has created barriers in knowledge transfer and the continuation of traditional practices.
2. This research showed how the historical caste-based discrimination have predisposed the Tamang peoples of Mathillo Sigarche to live in precarious conditions. People find it challenging to escape deep-rooted vulnerability due to the combination of a vicious cycle of poverty as well as increased landslide incidences associated with the 2015 Gorkha earthquake, poorly engineered roads and waning household and community efforts around landslide mitigation. Additionally, to make the situation worse, climate change is understood exaggerating volatility in landslide occurrence across the Himalayas (Eyler et al., 2022).

3. This research also showed that the frequent small- to medium-scale landslides can substantially increase people's vulnerability by straining their material and mental capacity to cope with future hazards. However, the state, media and aid agencies often undermine such smaller events, imposing a form of 'slow violence' (Nixon, 2011) on the poor and marginalized people, leaving them to deal with such hazards on their own (Marulanda et al., 2010; Tennakoon et al., 2021). Continued overlooking of such small- to medium-scale events can exaggerate the vulnerability of marginalized groups and jeopardize the achievement of the targets and commitments of SDGs and Sendai Framework for Disaster Risk Reduction (UN General Assembly, 2015; UNDRR, 2016).
4. This research has also highlighted that despite a growing call for the community participation and incorporation of local knowledge and culture in DRR efforts, community participation was found mostly limited to 'consulting' and 'enticing' in most CBLRR measures reviewed in systematic literature review (Chapter 4). Discussions with DRR practitioners and authorities during my fieldwork echoed this finding. Very few examples were available showing higher levels of people's participation. Such CBLRR measures—often driven by 'outsiders' are not enough to challenge the underlining causes of vulnerability (Šakić Trogrlić, 2020).
5. Similarly, despite a shift in global, national, and local policies that encourage to give greater attention to pre-disaster risk reduction measures, the efforts of decentralized local governments in Nepal appear inadequate to address the issues and vulnerabilities of marginalized people. The state institutions at local, district, provincial and federal levels must take more proactive and holistic steps to ensure the disaster/landslides-related issues and aspirations of marginalized people are accommodated in their plans and practice. The evidence from the ground suggests that decentralization of roles for DRR have not been accompanied with devolution of resources and effective governance and accountability mechanisms. Consequently, a better governmental presence and action for proactive landslide risk reduction is not felt by many grassroots communities like Tamangs of my study area.
6. This research also demonstrated the benefits of collaborating with local people and in bringing together local and scientific knowledges in landslide risk monitoring and reduction measures. Through participatory landslide monitoring component of the research, this research integrated the knowledges of 'certified' and 'uncertified'

experts to co-produce shared insights about landslide risks and risk reduction. The participatory process followed in this research yielded many co-benefits. These include the identification, documentation and addressing of gaps and challenges in current local and institutional landslide monitoring and prediction methods (see Chapter 6 and 7). It also enabled pinpointing crucial questions about rainfall, soil moisture and acoustic emission characteristics that the local people and stakeholders deemed useful for exploration. Other benefits include the installation of sensors and subsequent slope monitoring works with good community participation, and triangulation of instrumental data with observational data as required. Participatory landslide monitoring also provided a platform to open dialogue about other 'everyday' and landslide issues and their potential solutions. In a nutshell, participatory processes give voice and agency to the marginalized populations (Gumiran & Daag, 2021), but such process should be conducted after careful assessment of community power dynamics to prevent or mitigate the 'elite capture' (Tran & Kim, 2023).

7. The analysis of year-long rainfall, soil moisture and acoustic emission data have explored valuable information about the rainfall and soil moisture characteristics and corresponding slope deformation status of the monitored sites. The monitored data showed the seasonal patterns of rainfall and soil moisture data with higher values during the monsoon. It also showed how the soil moisture levels at different depths is influenced by timing and season (atmospheric drying and wetting processes), rainfall characteristics and local site conditions (for example, the potential role of preferential flow paths in Mathillo Sigarche, and role of ground water table in Tallo Sigarche).
8. Finally, in absence of extreme precipitation events and active slope deformation, I could not establish the clear empirical relationship between acoustic emission and rainfall. However, at Tallo Sigarche, all the higher values (daily acoustic emission values higher than 250 RDC) of the available daily acoustic emission data occurred during monsoon. This indicates the potential role of daily and antecedent rainfall in acoustic emission generation, emphasizing the need for extra caution during the monsoon. The haphazard construction of rural roads using heavy equipment, which the local inhabitants suggest occurs even during the monsoon, should be discouraged to reduce landslide risk. In nutshell, the acoustic emission sensors demonstrated their ability to

monitor even small magnitudes of slope deformation continuously at high temporal resolution (Dixon, Codeglia, et al., 2015).

8.3.2 Limitations of the study

The timing of research was a key limitation of this study. Unfortunately, the pre-planned fieldwork overlapped with the COVID-19 pandemic causing pause and delays in the fieldworks and data collection. Consequently, some adjustments in research design and focus had to be done. During my seventeen months of fieldwork (May 2021-October 2022), I had to suspend my participant observation and face-to-face interactions at least 5 times due to the incidences of different waves of COVID-19 pandemic, consecutive travel restrictions and stay-at-home mandates from government, and conditions of self-isolation when I tested positive or was in close contact with someone having symptoms. While I tried to remain connected with my local research participants via regular phone calls and messenger calls, I could only do so with the people having access to mobile phones. Communicating with many people having poor access to mobile phones and internet was challenging during this period. The repeated restrictions on face-to-face interactions and participant observation led me to decide to focus more in one of the two villages for my detailed ethnographic work.

At the start of my fieldwork, my plan was to divide my time over two villages differing in terms of ethnic composition. Mathillo Sigarche, inhabited by Tamangs, contrasted with the mixed settlement of Tallo Sigarche, where Chhetris form the dominant population in terms of number. In Nepalese societies, Chhetris represent so-called higher caste groups and generally have higher socio-economic status compared to indigenous Tamangs. My intention was to conduct a comparative analysis of the findings. I believe the comparison would have further enriched my findings and arguments. However, this original plan had to be changed to focus more on Mathillo Sigarche due to the impacts of the pandemic. Nonetheless, the participatory landslide monitoring component of the research (as explained in Chapters 6 and 7) was carried out in both villages. Moreover, although not as rigorous as the intensive ethnographic approaches employed in Mathillo Sigarche, the research used other data collection methods such as in-depth unstructured and semi-structured interviews at Tallo Sigarche. These interviews provided me with valuable insights into the local context and dynamics concerning landslide risk and risk reduction efforts in Tallo Sigarche.

Another limitation of this research is the lack of incorporation of perspectives from Newar moneylenders, who hold official ownership of a significant proportion of the land in Mathillo Sigarche where many local Tamang families live and cultivate. Incorporating their narratives could have enriched the context and provided additional viewpoints for contextualization and discussion.

My inadequate Tamang language competency was inevitably another limitation of this research. While I had learnt some key Tamang terms and sentences, a better local language fluency would have been valuable for the ethnographic research in a setting such as this. On multiple occasions, I felt an increase in intimacy and acceptance when I was able to use some words of the local language. I had planned to mitigate the possible communication problems by recruiting a local translator. However, such incidences were rarely encountered as almost all the people I met could understand and communicate in Nepali.

Likewise, despite my efforts in early identification and fixing technical issues, the instrumental data, particularly the weather data (rainfall and soil moisture content), encountered some gaps and outliers primarily due to network issues and sensor failures. This required the use of only the parameters and time-period having regular and usual data in our analysis informing Chapter 7 of this research.

8.3.3 Recommendations for further research

This research was an attempt to unveil the grounded realities of a historically disenfranchised group, the Tamangs, in living with landslide risks. Besides highlighting the past and contemporary political and socio-cultural processes influencing their knowledge and strategies of dealing with landslide risks and impacts, this research also sought to bring together local knowledges with scientific knowledge to explore an innovative as well as culturally and socio-economically viable method of landslide monitoring to contribute to landslide risk reduction. In this section, I share some ideas for further research:

1. Using insights from political ecology and cultural approaches, this research has illustrated the availability and use of a variety of knowledges and strategies amongst Tamangs in dealing with landslide risks and vulnerabilities. This study has also uncovered the deeper root causes of local people's vulnerability to landslide risks.

There is a great opportunity to expand similar research to other geographical, socio-political, and cultural contexts to give due recognition and voice to the long-lasting but often hidden struggles of diverse groups, often exposed to different hazards and 'everyday' hardships. Likewise, there is further scope to compare the findings with the knowledges and strategies of socially privileged groups.

2. Although this research has briefly assessed and presented the impacts on and the perspectives and actions of Tamang women using the broader political ecology framework, there is further scope for a closer interrogation using the feminist political ecology approach (see, for example, Yadav et al., 2021) to explore the gendered differences and perspectives on landslide risk in more detail.
3. This research showed that the frequent exposure to less severe hazards like small-to medium-scale landslides can be a cause of extensive cumulative losses. This is at odds with the tendency of most disaster researchers, media, donor agencies and government authorities that give more attention to less frequent but extreme hazards. More research is necessary to create further evidence of the impacts of small- and medium-scale hazards on poor and marginalized families. Future research could assess the economic impacts in the form of proportion of household income lost, for example. This will help to bring focus upon the scale of losses associated with small- and medium-scale hazards. Merely presenting the impacts in economic figures fails to articulate a case to government and decision makers as it does not fully portray the scale of local seriousness of such impacts.
4. The acoustic emission sensors installed at the monitored sites showed the slopes were generally stable during the monitored period. The acoustic emission sensor was found able to continuously detect and quantify even smaller magnitudes of deformation with high temporal resolution. However, in absence of extreme precipitation and active slope deformation, I could not establish a clear empirical relationship of acoustic emission with rainfall and soil moisture levels. While people were interested to know the slope stability status, the local stakeholders were curious to know the behaviour of slope movement in response to rainfall and soil moisture fluctuations. Continued monitoring will bring more clarity about the slope behaviour across different times in a year, and corresponding antecedent rainfall and soil moisture conditions. Post event analysis when a landslide occurs or when the precipitation crosses official thresholds

can bring useful insights about slope deformation behaviour in response to rainfall, seismic shaking and natural or anthropogenic triggering mechanisms. It would also be interesting to explore if the decision makers are more receptive to public concerns when local people approach them scientific evidence of slope instability.

5. In this research, the role of instrumental data in reinforcing or changing people's perception about rainfall, soil moisture and slope stability status were assessed primarily during the preliminary and final sharing meetings. In future, this could be compared more systematically. The lack of easy access to live instrumental data meant that the local research collaborators had to rely on my preliminary and final sharing to understand what the instrumental data suggested. This meant the comparison had to be based on people's memory which may or may not reflect the reality for reasons elaborated in Section 6.3 of Chapter 6. In similar research in the future, researchers could explore if local people/students would be interested to document their key observations of weather and slope instability on their diaries (LaFay, 2023) and/or take regular photographs/videos using their mobile phones (Smith et al., 2022) such that the comparison with the instrumental observation and multi-directional cross-validation become easier and evidence based (Malone et al., 2022). This will help to highlight the strengths and gaps of each knowledge system and identify areas of convergence and divergence, and facets for complementarity and incompatibility (ibid). It is worth noting that during the final sharing meetings, my research participants demonstrated their willingness to contribute towards the proposed research direction, suggesting promising prospects for future research endeavours.
6. If I could restart this research again, I would prioritize the collaborative development of a publicly accessible data visualization platform for disseminating the current and past data of selected slope monitoring parameters from the earlier stages of the research. While a dashboard to display these values in graphical forms has been prepared, its creation occurred in the latter stages of the research with limited consultation with local people and stakeholders, because such development was not initially part of my plan (see Figures 7.19 and 7.20 for screenshots of dashboard). This means, when the dashboard was developed, I was already back in the UK for analysis and write-up after completing my fieldwork. This hindered my ability to extensively discuss and share its features and accessibility methods with local collaborators.

Consequently, the current dashboard has not gained much popularity among local inhabitants and stakeholders. Future research may consider developing the data visualization and dissemination strategy through participatory approaches. This also helps with my recommendation mentioned in point number 5 above, enabling people to make instant comparisons between their observations and instrumental data.

Furthermore, the existing dashboard does not include data about slope instability (acoustic emissions) due to absence of automated data transmission features in the acoustic emission sensor used in this research. Future research may use the sensors equipped with provisions for data transmission to online platforms. This would not only enable the integration of acoustic emission data into the dashboard but also help in remote monitoring of the slope stability status as well as functionality of the instruments. Moreover, this would avoid the need to travel to sites for downloading data for analysis, enabling quicker analysis and dissemination. Additional benefits include the protection of data in case of physical damage to instruments due to landslides, water soaking or other problems.

7. As mentioned in different sections, the slope-specific landslide monitoring using rainfall, soil moisture and acoustic emission sensors have also been carried out by Sajag-Nepal project in 8 other locations across Nepal[65]. Future research endeavours could also explore if the slope-specific data about slope characteristics, rainfall, soil moisture levels and slope deformation collected from the monitored sites, including those from my research sites, could be used to upscale the findings representative of a wider geographical scale. Such endeavour could aid in enhancing government advisories for landslides, thereby addressing the knowledge gap associated with the vagueness and lack of spatial-temporal specificity in general weather advisories.

[65] Two each in Sindhupalchok, Dolakha, Kavre and Myagdi districts. With two sites monitored through my research, the total number of slopes monitored using similar instrumentations is ten.

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Appendices

Appendix 1: Participant Information Sheet

Participant Information Sheet

Project title: Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction

Researcher: Ramesh Shrestha

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You are invited to take part in a study that I am conducting as part of my PhD research at Durham University. This study has received ethical approval from the ethics committee of Department of Geography of Durham University. Before you decide whether to agree to take part it is important for you to understand the purpose of the research and what is involved as a participant. Please read the following information carefully. Please get in contact if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

Nepal is prone to multiple hazards. Out of many hazards, landslides are one of the most significant hazards that takes hundreds of lives and causes millions of rupees of property damage each year. Through my research I want understand the physical and socio-economic causes of landslide vulnerabilities. This research focuses on exploring the interconnections between landslide science, and in particular local level mitigation measures, and culture.

This research is funded by the UK Global Challenges Research Fund (GCRF) through a PhD studentship awarded to me. The study has started in February 2019 and is expected to end in January 2022.

What are the research questions?

The broad objective of my research is to identify and study the key issues related to landslides risk reduction. The research aims to answer following research questions:

i. What are the reasons for the success/failure of existing community-based landslide risk reduction efforts?

ii. What are the socio-cultural institutions and processes influencing different local knowledges about landslides, and how do these inform strategies for landslide risk reduction?

iii. How can scientific and local knowledges be more effectively integrated to develop socio-culturally attuned landslide risk reduction measures in the federal decentralising era of Nepal?

Why have you been invited to take part?

As part of data collection for the research, I will interview community people and key stakeholders (government officials, local politicians, academicians, local teachers and NGO practitioners) to understand the local context, needs and gaps in terms of landslide risk reduction.

Do you have to take part?

Your participation is entirely voluntary, and you do not have to agree to take part. If you do agree to take part, you can withdraw at any time, without giving a reason. These interviews will take place at a time and place that are convenient for both of us.

What will happen to you if you take part?

If you agree to take part in the study, you will give me an interview which can take up to one hour and will involve different issues relating to landslide vulnerabilities, risks and risk reduction measures in Nepal. You can skip any question you do not answer and also can stop at any point if you do not feel comfortable or simply do not want to continue. Anonymised extracts from the interview may be quoted in the outputs from my research in the form of my dissertation, conference presentations, and published papers.

Are there any potential risks or benefits involved?

There is no direct benefit for you to participate in the research. There is also no payment for your participation. However, my overall aim is to feed into a better understanding of how to reduce the landslide risks in Nepal. The findings will also be used to influence policy makers at different levels in planning, preparing and implementing effective landslide risk reduction measures, hence for public benefit.

In terms of risks, local people living in landslide prone areas might experience bitter relation with local government representatives and politicians in case they feel that locals provided information against them. To mitigate any potential risk, I will anonymise all the information obtained from you and your name or identity, or the name of your organization will not be disclosed in any way. All the data will be stored in a safe location accessible only to me.

Will your data be kept confidential?

The data you provide is fully anonymous and we will not collect or ask you to provide any sensitive personal data that might put you in risk or harm. Signed consent forms and original audio recordings will be retained in secured arrangement and only the researcher will have access to it.

Thank you for reading this information and considering taking part in this study.

Kind Regards,

Ramesh Shrestha | Doctoral Researcher, Department of Geography, Durham University, UK
Email: ramesh.shrestha@durham.ac.uk Contact: (+977) 9841-679637

Appendix 2: Participant Information and Consent Form

"Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction"

Information and Consent Form

Thank you for kindly agreeing to be interviewed for the PhD research titled, **"Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction."** This research focuses on exploring the interconnections between landslide science, and in particular local level mitigation measures, and culture. Using Sindhupalchok of Nepal as a case study site, this research intends to understand physical and socio-political causes of landslide vulnerabilities.

This research is funded by the Global Challenges Research Fund (GCRF) through a PhD studentship awarded to Ramesh Shrestha, a PhD researcher in the Department of Geography at Durham University.

With your agreement, I would like to use the information that you kindly share with me today in academic and wider publications, and disseminations.

Please complete the following:

- ☐ I……………………………………… voluntarily agree to participate in this research study.
- ☐ I understand that I will not get any remunerations from participating in this research.
- ☐ I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.
- ☐ I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.

☐ I have had the purpose and nature of the study explained to me in verbal/writing and I have had the opportunity to ask questions about the study.

☐ I agree to my interview being audio-recorded or recorded in a notebook.

☐ I agree to being video-recorded.

☐ I understand that all information I provide for this study will be **treated confidentially**.

☐ I agree for you to use the interview material gathered today with my identity remaining anonymous. However, I agree to you mentioning my broad affiliation e.g. 'representative of NGO', 'academician', and 'community member' etc.

☐ I agree that the researcher has explained me that the signed consent forms and original audio recordings will be retained in secured arrangement and only the researcher will have access to it.

☐ I understand that a transcript of my interview in which all identifying information has been removed will be retained for a specific period of time.

☐ I understand that under freedom of information legalisation I am entitled to access the information I have provided at any time while it is in storage as specified above.

☐ I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Name of Interviewee:	Name of researcher: Ramesh Shrestha

Appendix 3: Project Summary Sheet

"Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction"

Tentative target audience: Community members, Local authorities, local NGO workers, INGO workers, academics, national level stakeholders

Project Summary

Nepal is a mountainous country highly susceptible to different geophysical and hydro-meteorological hazards such as earthquakes, floods, landslides, lightning and droughts. Each year, disasters cause substantial economic and human losses, affect thousands of people and damage many critical infrastructures. More than 1.085 million private houses were damaged and over 7 billion USD of financial loss was incurred between 2015-2016 due to different disasters in Nepal, with 2015 Gorkha earthquake and its aftershocks being the major cause of loss during the period.

Out of many hazards that affect Nepal and Nepalese communities, landslides are one of the major hazards of Nepal. The proposed research entitled, **"Exploring synergies and opportunities at the interface between culture, ritual and science for landslide risk reduction"** aims to explore the interconnections between landslide science, and in particular local level mitigation measures, and culture. Using Sindhupalchok as a case study site, this research seeks to better understand local vulnerabilities to landslides; document local knowledge around landslide hazard and risk; and explore the potential for integrating local knowledge and science to reduce landslide risks. The findings will be presented in my thesis, published academic papers, guidelines to government, and in presentations back to my participants at the end of the research.

This research has been funded by Global Challenges Research Fund (GCRF) and was started in February 2019 and is expected to end in May 2023. The study aims to answer following research questions using range of ethnographic tools such as participant observation and interviews:

i. What are the reasons for the success/failure of existing community-based landslide risk reduction efforts?
ii. What are socio-cultural institutions and processes influencing different knowledges about landslides, and how do these inform strategies for landslide risk reduction?
iii. How can scientific and local knowledges be more effectively integrated to co-develop appropriate and effective landslide risk reduction measures that builds on local knowledge and the knowledge of 'certified' scientists?

Kind Regards,

Ramesh Shrestha | Doctoral Researcher, Department of Geography, Durham University, UK

Email: ramesh.shrestha@durham.ac.uk Contact: Phone/Whats app: (+977) 9841-679637

Appendix 4: Interview checklist

Ethnographic semi-structured interview checklist for interviews with NGO practitioners/academics/government officials (Texts are in English and Nepali language)

Section 1 My introduction including ethical statement

My name is Ramesh Shrestha, and I am a postgraduate student at Durham University. I am conducting my research about landslides risk reduction from Durham University. This research has been funded by Global Challenges Research Fund (GCRF) and was started in February 2019 and is expected to end in January 2022. I am currently collecting information for having better understandings about the socio-cultural institutions and processes influencing different local knowledges about landslides and the ways these inform strategies for landslide risk reduction. You can finish the interview when-ever you desire. You do not need to complete or answer any questions that you do not wish to answer. The data you provide is fully anonymous and we will not collect or ask you to provide any sensitive personal data that might put you in risk or harm.

Do you have any questions about what I just explained? In course of our interaction, if you want to give me additional information or ask anything for clarification, please do so. Are you okay to give opinions and information about my questions? Some of the questions are specific to Tamang people. If you don't have idea about Tamang specific response, please feel free to respond in relation to other ethnic groups that you have worked with. However, please specify, if your response is specific for particular ethnic groups or can be generalized for all.

A) Causes and effects of landslides
पहिरोका कारण र असरहरु

1. Each year, landslides cause substantial economic and human losses, affect thousands of people and damage many critical infrastructures in Nepal. In your opinion, how are the landslides occurrences and impacts changing spatially and temporally over time in Nepal [Is the nature (size, types, frequency, timing, location, and severity) of landslides changing with time]? What might be the reasons for change?
नेपालमा पहिरोका कारण हरेक वर्ष उल्लेखनीय मात्रामा जनधनको क्षति हुनुका साथै हजारौँ मानिसहरु प्रभावित हुने र थुप्रै आधारभूत संरचनाहरुमा क्षति पुग्ने गरेको छ। यहाँको विचारमा पहिलेको तुलनामा अहिले, पहिरो र त्यसले निम्त्याउने क्षतिमा केही परिवर्तन आएको छ ? यदि छ भने यहाँको विचारमा पहिरोको प्रकृति (आकार, प्रकार, आउने समय, बारम्वारता र जाने स्थान) मा कस्तो खालको परिवर्तन आएको छ? अनि परिवर्तनको कारण के होला ?

2. What are the major (direct and indirect) impacts of landslides on lives and livelihoods of people?
पहिरोले मानिसहरुको जीवन र जीविकामा प्रत्यक्ष र अप्रत्यक्ष रुपमा निम्त्याउने मुख्य असरहरु के के हुन् ?

a. Follow-up question: Are there variance in impacts of disasters to different groups (in terms of age, gender, ethnicity, livelihood groups, distance from the main body of landslide etc.)

के ती असरहरु फरक फरक समुहहरु (जस्तै: विभिन्न उमेर, लिङ्ग, जातीयता, जिविकापार्जन समूह, पहिरो भएको स्थानबाट वसोवासस्थलवीचको दूरी आदि) का लागि फरक फरक छन्?

b. If yes, how are the impacts different to different groups? (What precise groups and classes do landslides affect adversely?

यदि फरक छन् भने कसरी पहिरोको असर फरक फरक समूहहरुका लागि फरक फरक छ? यहाँको विचारमा कस्ता समूह र वर्गहरु पहिरोबाट बढी प्रभावित हुन्छन वा हुन सक्छन ?

c. Why do you think that there are differential impacts?

यहाँको विचारमा फरक फरक समुहहरुमा फरक फरक असर किन पर्छ होला?

d. Past incidences have shown that the groups like Tamangs are more vulnerable to landslides. Why do you think different groups are differentially vulnerable and impacted?

विगतका अनुभवका आधारमा तामाङ जस्ता समुदायहरु पहिरोबाट अति संकटासन्न अवस्थामा रहेका छन्। यहाँको विचारमा विभिन्न समूह वा समुदायहरु विपदबाट किन फरक फरक रुपमा संकटासन्न र प्रभावित हुन्छन?

3. In your view, in what way do these classes or groups most vulnerable to or affected by landslides perceive the causes of landslides and their impacts? And who do they think are primarily responsible for finding/implementing solutions to landslides?

यहाँको विचारमा ती पहिरोबाटअति संकटासन्न वा प्रभावित वर्ग वा समुदायले पहिरो किन जान्छ र त्यसले किन क्षति गर्छ भनी सोच्छन? त्यस्तै पहिरोको समाधान खोज्न र कार्यन्वयन गर्ने मुख्य जिम्मेवारी कसको हो भन्ने ठान्छन ?

4. In your own view, what are the major causes of landslides and the damage they cause?

यहाँको आफ्नै बिचारमा पहिरो र त्यसले गर्ने क्षतिको मुख्य कारणहरु के के हुन् ?

a. Follow-up question: What types of areas are more prone to landslides? Why?

कस्ता कस्ता क्षेत्रहरु पहिरोको बढी जोखिममा हुन्छन? किन?

b. What are the common preparatory factors (both natural and anthropogenic) that convert a relatively 'stable' slope into unstable or marginally stable areas?

के कस्ता दीर्घकालीन (long-term) प्राकृतिक र मानव सिर्जित कारणहरुले स्थिर भिरालो जमिनलाई अस्थिर बनाउन भूमिका निर्वाह गर्छन ?

c. What are some of the most common triggering factors in Nepalese contexts that cause landslides to move?

त्यस्तै नेपालको सन्दर्भमा पहिरोका तात्कालिक (short-term) कारणहरु के के हुन्?

d. Besides the landslides, what other hazards and stress factors affect people's preparing and coping capacities to landslides and other hazards?

नेपालको सन्दर्भमा पहिरोको अलावा अन्य के कस्ता प्रकोप र तनाव तत्वहरुले गर्दा मानिसहरुको पहिरोको सामना गर्ने क्षमता क्रमश: ह्रांस हुन्छ ?

B) Settlement, livelihood and landslide occurrence

बस्ती, जीविकोपार्जन र पहिरो

1. In your view, what are the general features of traditional settlements of groups like Tamangs (in terms of elevation, slope angle, aspect, curvature, distance from the gullies, soil productivity etc.)?

यहाँको विचारमा तामाङ जस्ता समुदायका परम्परागत वस्तीहरुको सामान्य गुणहरु (उचाई, भिरालोपना, खोल्सा-खोल्सीबाट दूरी, माटोको उर्बराशक्ति आदिका आधारमा) के के हुन् ?

a. Follow-up question: Is it different from the settlements of other ethnic groups, particularly the Chhetris and Brahmins?

के तामाङ बस्ती, क्षत्री ब्राह्मण लगायतका अन्य जात-जातिका बस्ती भन्दा फरक हुन्छन ?

b. If yes, how different is the settlement pattern from other ethnic groups?

यदि हुन्छन भने तामाङ र अन्य जात-जातिका बस्तीमा कस्तो खालको फरकपन पाउनु हुन्छ?

c. Do you think they have considered landslide hazard while deciding where to live?

यहाँको विचारमा तामाङ समुदायले परम्परागत बस्ती स्थापना गर्दा पहिरो लगायतका प्रकोपलाई मध्यनजर गरेका थिए ?

d. Is the settlement pattern of groups like Tamangs changing in general with time? If yes, how?

त्यस्तै , समयाक्रमानुसर तामाङ समुदायको बसोबास/बस्ती शैली परिवर्तन भएको छ कि? यदि छ भनी कस्तो किसिमले परिवर्तन भईरहेको छ ?

2. If people live in landslide prone areas, why do they live in such areas?

यदि मानिसहरु पहिरोको जोखिम भएको स्थानमा बस्छन भने के कारणले बस्छन?

a. Follow up question: When people have adequate income to live in a safe location but do not live, why do you think they choose not to do that?

यदि मानिसहरुसंग पहिरोबाट सुरक्षित स्थानमा बसोबास गर्न पुग्ने आम्दानी वा सम्पत्ति छ तर पनि सुरक्षित स्थानमा सर्दैनन भने किन नसर्दा रहेछन ?

b. What are the major actions people take to prevent or mitigate the risks in such areas?

पहिरोजन्य स्थानमा बस्ने क्रममा मानिसहरुले पहिरोको जोखिम रोकथाम वा अल्पिकरण गर्ने के कस्ता उपायहरु अपनाएका हुँदा रहेछन ?

3. Do you think there is any relationship between livelihood activities and location of settlements? If yes, please elaborate. (No need to answer if response is covered above).

यहाँको विचारमा बस्ति स्थान र जीविकोपार्जनका माध्यमबीच केहि सम्बन्ध छ त ? यदि छ भने, कृपया उदाहरण दिनुहोस।

4. How are livelihood activities and landslide vulnerabilities/occurrences interrelated? Could you please give examples based on your experiences?

त्यस्तै, जीविकोपार्जनका माध्यम र पहिरो संकटासन्नता वा पहिरोको घटनाक्रमबीच कस्तो सम्बन्ध छ ? आफ्नो अनुभबको आधारमा केहि उदाहरण दिनुहुन्छ कि ?

5. Is there any change in migration, land-use and settlement pattern? If yes, please elaborate the change.

यहाँको विचारमा अहिले पहिलेको तुलनामा वसाईसराइ, भू-उपयोग, र बस्ति शैलीमा केहि परिवर्तन आएको छ कि? यदि छ भने, कस्तो खालको परिवर्तन आएको छ?

a. Follow-up question: What are the primary reasons for such change? **यहाँको बिचारमा परिवर्तन आउनुको मुख्य कारणहरु के के हुन् ?**

i. For Migration (**बसाइसराइमा परिवर्तन आउनुको कारण**):

ii. For change in Land-use pattern (**भू-उपयोगमा परिवर्तन आउनुको कारण**):

iii. For change in settlement pattern (**बस्ति शैलीमा परिवर्तन आउनुको कारण**):

b. How has the migration and/or change in land-use and settlement pattern contributed to decreasing or increasing landslide risks and damages?

बसाइसराइ, भू-उपयोग, र बस्ती शैलीमा आएको परिवर्तनले पहिरोको जोखिम र क्षति घटाउन वा बढाउन कस्तो भूमिका खेलेको छ ?

6. What are the major livelihood activities of (Tamang) people? Is it different within (in terms of age groups, gender etc.) the groups and from other groups?

तामाङ समुदायको मुख्य मुख्य जीविकोपार्जनका उपायहरु के के हुन् ? के ति उपायहरु अन्य समुदायबाट फरक छन् ? के तामाङ समुदाय भित्रै पनि लिङ्ग, उमेर आदिका आधारमा जीविकोपार्जनका उपायहरु फरक फरक छन् ?

7. Are the livelihood activities (of Tamang people in general but please feel free to mention about other groups if you do not have idea about Tamang people) changing with time? If yes, please elaborate the nature of change.

के तामाङ समुदायको जीविकोपार्जनका माध्यमहरु समयक्रमानुसार परिवर्तन भैरहेको छ ? यदि छ भने, कस्तो खालको परिवर्तन पाउनुहुन्छ ? (यदि यहाँलाई तामाङ समुदायको बारेमा थाहा छैन भने आफुलाई थाहा भएको समुदायको बारेमा उल्लेख गर्नु होला)

a. Follow up: If agriculture or livestock rearing comes as one of the major livelihoods, what did they plant/rear traditionally and now?

यदि कृषि, पशुपालन जीविकोपार्जनको मुख्य उपाय मध्ये पर्दछन भने, परम्परागत रुपमा तामाङ समुदायले के खेती वा पशुपालन गर्ने गर्दथे ? र अहिले त्यसमा केहि परिवर्तन आएको छ कि ?

b. Why and how have the livelihood patterns and activities (including farming, water harvesting and cattle rearing methods and types) changed in relation to those practiced in the past?

कृषि, पशुपालन कार्य र शैली (जस्तै: वाली प्रकार, सिंचाई विधी, पशु प्रकार र पालनशैली आदि) मा पहिलेको तुलनामा अहिले किन र कस्तो खालको परिवर्तन आइरहेको पाउनुहुन्छ?

c. Does these changes affect the landslide risks and vulnerabilities? If yes, how?

के यी परिवर्तनले पहिरोको जोखिम र संकटासन्नतामा केहि असर गरेको छ त? यदि छ भने, कसरी ?

C.1) Indigenous and guided landslide risk reduction measures (If know examples from Tamang community, please highlight those examples)

परम्परागत/स्थानीय तथा निर्देशित पहिरो जोखिम न्यूनीकरणका उपायहरु (यदि यहाँलाई तामाङ समुदायकै उदाहरण थाहा छ भने तामाङ समुदायकै उदाहरण दिनुहोल। थाहा नभएको अवस्थामा अन्य समुदायको उदाहरण दिनुहोला।)

1. What intentional and unintentional actions do people (Tamang people) take at household and community levels without external support to reduce the risks of (avoid, mitigate, respond to or recover from) landslides (fall, topple, slide and flow) when they perceive that their land, houses or community are at risks of landslide? (Explore both religious and non-religious actions)

मानिसहरुले (तामाङ समुदायका मानिसहरुले) बुझेर वा नबुझिकन घर र समुदायस्तरमा पहिरोको जोखिम न्यूनीकरण र व्यवस्थापन गर्न वाह्य सहयोग बिना के कस्ता उपायहरु अपनाएका हुन्छन? (यदि ती मध्ये केहि धर्म कर्म वा रीतिस्थिति संग सम्बन्धित गतिबिधिहरु छन् भने पनि उल्लेख गर्नुहोस। जस्तै: पूजा आजा)

a. Are such activities different between male and female?

के ती उपायहरु महिला र पुरुषहरु बीच फरक फरक छन् ?

b. Are such actions different with respect to different age groups, economic status, or any other categorizations? If yes, how are they different?

त्यस्तै, के ती उपायहरु उमेर समूह, आर्थिक अवस्था, जीविकोपार्जनका प्रमुख उपाय, वा अन्य वर्गीकरणका आधारमा फरक फरक छन् त ? यदि छन् भने कसरी फरक छन् ?

c. What are the reasons behind such actions? Explain what factors influence the decision-making (For example: costs, rational comparison, decision of the household heads/village leaders/elites etc.) on household and community actions to avoid or mitigate landslides?

ती क्रियाकलापहरु गर्न निर्णय गर्दा के कस्ता कारणहरुले भूमिका खेल्छन ? कृपया ती क्रियाकलाप गर्ने निर्णय गर्दा के कस्ता कारणहरुले भूमिका खेल्छन उल्लेख र ब्याख्या गर्नुहोस । (जस्तै: लाग्ने खर्च,

भएको परम्परागत ज्ञान सिप, घरमुली वा समुदायको अगुवाको निर्णय, गुम्बा वा धार्मिक संस्थाको सल्लाह वा निर्णय आदि)

d. In your view, does such measures promote or hinder disaster risk reduction?
यहाँको विचारमा ती क्रियाकलापले विपदको जोखिम बढाउँछ वा घटाउँछ ?

e. Are such actions different now from the ones before xxx periods of time?
के ती क्रियाकलापहरु पहिलेको तुलनामा अहिले फरक हुँदै छन् ? यदि छन् भने कसरी ?

2. What social provisions or informal institutions are there in place to mitigate landslide risks and/or support the people in need, including the ones affected by landslides? How do these prioritize the beneficiaries? Why are they prioritized?
पहिरोको जोखिम न्यूनीकरण गर्न र/वा अप्ठ्यारोमा परेका मानिसहरुलाई सघाउन समुदायमा (तामाङ समुदायमा) के कस्ता अनौपचारिक संघ-संस्था वा परम्परागत सामाजिक व्यवस्थाहरु छन् ? ती व्यवस्था वा संघ-संस्थाले कसरी लाभग्राहीहरु प्राथमिकीकरण गर्छन?

3. Are there examples of local ceremonies, festivals, social norms, customs and beliefs that people follow that can be linked with disaster/landslide risk reduction?
विपद/ पहिरो जोखिम न्यूनीकरणसंग जोड्न मिल्ने स्थानीय समारोह, प्रथा, उत्सब, चाडपर्व, सामाजिक रिवाज, र आस्थाका केहि उदाहरणहरु छन् भने उल्लेख गर्नुहोस।

a. Follow up: Among these, what practices are still practiced and what are no longer practised?
ती मध्ये के के प्रथाहरु अझै चल्तीमा छन् र के के प्रथाहरु लोप भई सके ?
b. Follow up: What might be the reasons for continuation and abandonment?
प्रथाहरु चल्तीमा रहनु र लोप हुनुको कारणहरु के के हुन् ?

4. In your view, how does knowledge transfer take place between different social groups and generations?
यहाँको विचारमा विभिन्न समूहहरु र पुस्ताहरु बीच परम्परागत रुपमा ज्ञानको हस्तान्तरण कसरी हुने गरेको छ ?

a. Are there any folklores, songs, paintings or myths that might be relevant for landslide risk reduction?
यहाँलाई पहिरो जोखिम न्यूनीकरणसंग सम्बन्ध जोड्न सकिने कुनै संस्कृति, दन्त्यकथा, लोकोक्ति, गीत-संगीत, चित्रकला आदि बारे केहि जानकारी छ भने उल्लेख गर्नुहोस।

b. Who in the community would be best to contact with for learning about such folklores, songs, paintings, or myths?
समुदायमा ती संस्कृति, दन्त्यकथा, लोकोक्ति, गीत-संगीत, चित्रकलाबारे थप जानकारी लिन परेमा कोसंग सम्पर्क गर्दा उपयुक्त होला ?

5. Are there any other indigenous knowledge or belief system, ceremonies or practices you find influence, promote or hinder practices on landslides risk reduction? If yes, give examples.

पहिरो जोखिम न्यूनीकरणलाई प्रभावित गर्ने, बढावा दिने वा बाधा पुर्याउने छलफलमा आइसकेका बाहेकका अन्य थप केहि परम्परागत ज्ञान, संस्कृति, आस्था, समारोह, उत्सब, चाडपर्ब, रिति-रिवाज आदि भए उल्लेख गर्नुहोस।

6. Have you encountered/witnessed any opportunities or challenges associated with local/Tamang culture in planning and implementing landslide risk reduction intervention? If yes, could you please elaborate?

यहाँले पहिरो जोखिम न्यूनीकरणका क्रियाकलापहरुको योजना तर्जुमा गर्दा वा कार्यन्वयन गर्दा स्थानीय/तामाङ संस्कृतिसंग सम्बन्धित केहि अवसर वा चुनौतिहरुको सामना गर्नु परेको छ ? यदि छ भने वर्णन गर्नुहोस।

7. What are the common guided/formal processes and measures promoted/supported to reduce the risks of landslides in communities by government and other actors (for examples, NGOs, CSOs)?

नेपालमा सरकारी तथा गैर-सरकारी निकायहरुले पहिरोको जोखिम न्यूनीकरणका लागि समुदाय स्तरमा सघाउने गरेका प्रायजस्ता औपचारिक प्रक्रिया र गतिविधिहरु के कस्ता छन् ?

a. Follow up: Do you think these measures have integrated indigenous/cultural knowledge in planning and implementation?

नेपालमा सरकारी तथा गैर-सरकारी निकायहरुले पहिरोको जोखिम न्यूनीकरणका लागि समुदाय स्तरमा सघाउने गरेका प्रायजस्ता औपचारिक प्रक्रिया र गतिविधिहरु के कस्ता छन् ?

b. What do you think the government and other actors are doing to integrate indigenous/cultural knowledge to reduce landslide risks?

यहाँको बिचारमा सरकारी तथा गैर-सरकारी निकायले पहिरो जोखिम न्यूनीकरणका नीति-नियम र योजना तर्जुमा र कार्यन्वयन गर्दा स्थानीय ज्ञान-सिप र संस्कृतिलाई समेट्न के कस्ता प्रयासहरु गरेका छन् ?

c. What do you think the government and other actors can do better to integrate indigenous/cultural knowledge to reduce people's risk to landslides?

यहाँको विचारमा सरकारी तथा गैर-सरकारी निकायले स्थानीयको पहिरो जोखिम कम गर्ने क्रममा स्थानीय ज्ञान-सिप र संस्कृतिलाई समेट्न थप के गर्दा उपयुक्त होला ?

8. Derived from your past experience/research, what are the most appropriate ways to reduce landslide risks in terms of suitability from feasibility, cost effectiveness, time required and overall benefits? Please mention in descending order of their effectiveness (from feasibility, cost effectiveness, time required and benefitting the vulnerable) (In terms of preparedness, mitigation, response and recovery) (You can include the points mentioned above.).

यहाँको अनुभब र अध्ययनको अनुसार नेपालको सन्दर्भमा सम्भाव्यता, लाग्ने खर्च र समय, बिध्यमान ज्ञान र क्षमता तथा समग्र फाइदाका आधारमा पहिरोको जोखिम घटाउने उपयुक्त उपायहरु के के हुन सक्छन ? कृपया महत्व र प्रभावकारिताको आधारमा क्रमश उल्लेख गर्नुहोस (१=अति प्रभाबकारी)

a. How can/should the communities be engaged in those interventions?

समुदायलाई ती क्रियाकलापहरुमा कसरी संलग्न गर्न सकिएला वा गर्न पर्ला ?

b. Please also mention, who do you think should be primarily responsible for the implementation of those interventions. Please be specific in mentioning the actor (For example, NDRRMA, MOHA, DHM, Department of Mines, and/or Local/Province Government instead of Government in general)

यहाँको बिचारमा ती क्रियाकलापहरु कार्यन्वयन गर्न मुख्य जिम्मेवार व्यक्ति वा निकाय को होला ? (जिम्मेवार व्यक्ति वा निकाय उल्लेख गर्नु हुँदा जति मिल्छ स्पस्टताका साथ उल्लेख गर्नु होला)

c. What are the other stakeholders that either have mandate or interest in contributing to the implementation of those interventions.

ती क्रियाकलापहरु कार्यन्वयन गर्न अधिकारप्राप्त वा इच्छुक हुन सक्ने अन्य सरोकारवालाहरु को को हुन सक्छन ?

C.2) Early Warning System

पूर्व सूचना प्रणाली

1. How people (most specifically Tamang people) traditionally know when and where a landslide might happen? Are there any warning signs or symbols are used by people traditionally to predict likelihoods of landslides?

परम्परागत रुपमा मानिसहरुले (विशेषत: तामाङ समुदायका मानिसहरुले) कहिले र कहाँ पहिरो जान सक्ला भनि कसरी थाहा पाउने गर्थे ? के मानिसहरुसंग परम्परागत रुपमा पहिरो पूर्वानुमान गर्नका संकेत वा माध्यमहरु थिए वा छन् ?

a. Follow up: If yes, what are these signs or symbols?

यदि थिए वा छन् भने, ती संकेत वा माध्यमहरु के कस्ता थिए/छन् ?

b. How is it different from people to people in terms of gender, livelihoods, proximity of houses from the landslides/gullies, etc.?

के ती संकेतहरु लिङ्ग, उमेर, जीविकोपार्जनका उपाय, पहिरो/खोल्सा-खोल्सी र घर बिचको दूरीका आधारमा मानिस-मानिसबीच फरक फरक छन् त ? यदि छन् भने कसरी फरक छन् ?

c. Do you think they are still relevant?

यहाँको बिचारमा ती संकेतहरु अझै सान्दर्भिक छन् त ?

d. What sort of areas are generally considered safe or vulnerable to landslides?

कस्ता खालका ठाउँहरु पहिरोबाट सुरक्षित र असुरक्षित मानिन्न्थ्यो/मानिन्छ ?

2. If locals have to communicate some important message (in general, for example, communal meetings/gatherings, important news etc.) amongst each other, how do they communicate?

स्थानीयहरुले (**तामाङ समुदायका मानिसहरुले**) **एक-अर्कामा यदि कुनै महत्वपूर्ण संदेशहरु प्रवाह गर्नु पर्दा कसरी आदान-प्रदान गर्ने गर्दथे/गर्छन** (**उदाहरणका लागिः सामुदायिक वैठक/भेला, महत्वपुर्ण सूचना आदि**)?

3. How do people (Tamang) transfer knowledge if certain areas are affected by landslides in the past or prone to future landslides?

यदि कुनै ठाउँमा पहिरो गएको थियो वा भविष्यमा पहिरो जान सक्छ भन्ने थाहा भएमा तामाङ समुदायका मानिसहरुले एक-अर्कामा कसरी जानकारी आदान-प्रदान गर्छन ?

a. Who do they mostly communicate the information?

उनीहरुले त्यस्ता सूचना प्राय कसलाई र कसरी दिने गर्छन ?

b. Compare between the past and present modes of communication.

विगत र अहिले प्रयोग हुने माध्यमबारे तुलनात्मक रुपमा जानकारी दिनुहोस।

4. What do the people generally do after they know or get information about the risks of landslide occurrences?

पहिरोको जोखिमबारे थाहा पाएपछि मानिसहरुले प्रायजसो के के गर्ने गर्थे/गर्छन ?

a. Are the actions different with respect to different age groups, gender, economic status, or any other categorizations? If yes, how are they different?

के ती क्रियाकलापहरु फरक फरक उमेर, लिङ्ग, आर्थिक अवस्था, वा अन्य वर्गीकरणका माध्यमका आधारमा फरक फरक छन्? यदि छन् भने के कसरी फरक छ ?

b. Who and how do people contact/rely for support in times of landslides?

पहिरोको समयमा मद्ददका लागि मानिसहरुले कोसंग र कसरी सम्पर्क गर्छन वा भर पर्छन ?

5. Have you heard, studied or been part of any landslide early warning system in practice at local, district and/or national level promoted/supported by government or non-governmental organizations in Nepal? Please explain briefly about those systems.

के तपाई स्थानीय, जिल्ला र/वा राष्ट्रिय तहमा संचालित पहिरो पूर्व सूचना प्रणालीबारे जानकारी वा अनुभव छ ? **यदि छ भने, कृपया छोटकरीमा वर्णन गर्नुहोस।**

a. Follow up: What is the landslide monitoring mechanism? What is monitored? How?

पहिरोको अनुगमन प्रणाली कस्तो थियो ? **के अनुगमन गरिएको थियो/छ** ? **कसरी** ?

b. Who did/does what in the system? What is the role of communities (men, women, youths, elderly, people of different ethnicities etc.) in the system?

त्यस पूर्व सूचना प्रणालीमा संलग्न विभिन्न सरोकारवालाहरुको भूमिका के कस्तो थियो ? त्यस्तै, समुदाय (महिला, पुरुष, युवा, ज्येष्ठ नागरिक, विभिन्न जातजातिका मानिसहरु आदि) को भूमिका के कस्तो थियो ?

c. How are warnings issued/disseminated?
त्यस पूर्व सूचना प्रणालीमा जोखिमको चेतावनी कसरी आदान-प्रदान गरिन्थ्यो/गरिन्छ ?

d. How do people respond to warnings?
मानिसहरुले चेतावनीको सूचना पाएपछि के गर्ने गर्दथे/गर्दछन ?

e. What are the strengths and shortcomings of those systems?
त्यस पूर्व सूचना प्रणाली/प्रणालीहरुको सबल र दुर्बल पक्षहरु के के थिए/छन् ?

6. Most recently, Nepal government has initiated the weather forecast for three days and daily disaster bulletin. Have you read such bulletin? Who do you think are the target beneficiaries of such forecast?
विगत केहि वर्ष यता नेपाल सरकार मातहत जल तथा मौसम विज्ञान विभाग र राष्ट्रिय विपद जोखिम न्यूनीकरण तथा व्यवस्थापन प्राधिकरणले ३ दिन सम्मको मौसमी पूर्वानुमान र दैनिक विपद बुलेटिन प्रकाशन गरी विभिन्न माध्यममार्फत प्रचारप्रसार गर्ने गरेको छ । के तपाईले त्यस्ता बुलेटिन पढ्नु भएको छ ? यदि छ भने, यहाको बिचारमा ती पूर्वानुमान र बुलेटिनका लक्षित लाभग्राहीहरु को को हुन् ?

a. Follow up: Do you think such information are accessible to vulnerable people?
यहाँको बिचारमा ती सूचनाहरु संकटासन्न मानिसहरुको पहुँचमा छ त ?

b. Do you think such information is well understandable by vulnerable people?
यहाँको विचारमा ती सूचनाहरु संकटासन्न मानिसहरुले बुझ्ने खालका छन् त ?

c. What are people expected to do after getting information of the bulletin and forecast?
ती पूर्वानुमान र बुलेटिनमा उल्लेखित सूचना प्राप्त गरेपश्चात मानिसहरुले के गर्नु पर्छ भनी अपेक्षा गरिएको छ जस्तो लाग्छ ?

d. Do you think people in general did what they were expected to do? If no, explain why? Compare between who did and did not do as expected.
यहाँको विचारमा मानिसहरुले जे अपेक्षा गरिएको थियो सो अनुसार गरे त ? यदि गरेनन भने किन गरेनन होला, व्याख्या गर्नुहोस। कृपया अपेक्षाकृत प्रतिक्रिया गर्ने र नगर्ने बीच तुलना गर्नुहोस ।

e. Follow up: In your view, for what other purposes can such forecast be used?
यहाँको विचारमा ती मौसमी पूर्वानुमान सम्बन्धी सूचनाहरु अन्य के प्रयोजनमा प्रयोग गर्न सकिएला ?

7. What other monitoring and communication mechanisms (both traditional and top-down/scientific) are practiced in different locations to predict or forecast and communicate landslides' risks?

पहिरो सम्बन्धी पूर्वानुमान र खबर आदान-प्रदान गर्न विभिन्न स्थानमा अन्य के कस्ता अवलोकन तथा सूचना आदान-प्रदानका माध्यमहरु (परम्परागत र वैज्ञानिक दुवै प्रकारका) चलनचल्तीमा छन् ?

8. What potential roles can the new technologies and social media play in four different elements of landslide EWS [such as i) Risk Knowledge, ii) Monitoring and Observation, iii) Communication and Dissemination, and iv) Response preparedness]?

पहिरोका विभिन्न आयामहरु (जस्तै : जोखिमको ज्ञान, अनुगमन तथा अवलोकन सेवा, खबर आदान-प्रदान, र प्रतिकार्य पूर्वतयारी)मा नयाँ प्रविधि र सामाजिक संजालका माध्यमहरुको के कस्तो भूमिका रहन सक्ला ?

9. Based on your overall experience and thoughts, what are your suggestions for set-up/improvement of the landslide early warning system in Nepal in terms of feasibility, efficiency, cost effectiveness, overall benefits, community ownership and sustainability? Please highlight how communities and different stakeholders can be engaged in different steps and processes.

आफ्नो अनुभव र विचारका आधारमा नेपालमा पहिरो पूर्व सूचना प्रणाली स्थापना वा सुधारका लागि यहाँको के कस्तो सुझाब रहेको छ? कृपया यहाँको सुझाबका आधारमा पूर्व सूचना प्रणाली स्थापना वा सुधारको विभिन्न चरण र प्रक्रियामा समुदाय र विभिन्न सरोकारवाला निकायहरु कसरी संलग्न हुन वा गर्न पर्ला, सो पनि उल्लेख गर्नुहोस।

D) Trust, responsibility sharing, access to decision-making, and governance

भरोसा, जिम्मेवारी बाँडफाँट, निर्णय प्रक्रियामा पहुँच तथा सु-शासन

1. How do (Tamang) communities and households try to reduce and cope the impacts of landslides on lives, livelihoods and other resources (physical, economic, social)?

मानिसहरुले (तामाङ समुदायका मानिसहरुले) पहिरोबाट जीवन, जीविकोपार्जन, तथा अन्य भौतिक, आर्थिक, सामाजिक स्रोत-साधनमा पर्ने असर न्यूनीकरण कसरी गर्ने गर्छन ?

a. Follow up: What do (Tamang) people do to repair houses or reclaim land damaged due to landslides?

मानिसहरुले (तामाङ समुदायका मानिसहरुले) पहिरो बाट क्षति भएको घर र जमिन कसरी मर्मत-सम्भार गर्ने गर्छन ?

b. What are the examples of some collective actions that (Tamang) people take to reduce landslide risks?

पहिरोको जोखिम न्यूनीकरण गर्न मानिसहरुले (तामाङ समुदायका मानिसहरुले) गर्ने गरेका केहि सामुहिक क्रियाकलापको उदाहरण दिनुहोस।

2. If locals have to decide on communal activities, who do they consult/how is it done? (Special reference to village leaders, elected representatives, lamas, bombos etc.)
यदि स्थानीयहरुले (तामाङ समुदायका मानिसहरुले) कुनै सामुदायिक कार्य गर्न पर्यो भने, के कसरी गर्ने भनी निर्णय कसरी गर्छन ? (स्थानीय अगुवा, निर्वाचित पदाधिकारीहरु, लामा, बोम्बोको भूमिका रहन्छ भने पनि उल्लेख गर्नु होला)

3. Who are the major actors involved in landslide risk reduction?
पहिरो जोखिम न्यूनीकरणमा संलग्न प्रमुख सरोकारवाला निकाय वा व्यक्तिहरु (औपचारिक र अनौपचारिक दुवै) को को हुन् ?

a. In your view, whom do you think the people rely/trust to prepare for and mitigate landslide risks?
यहाँको बिचारमा मानिसहरुले पहिरोको पूर्वतयारी र अल्पिकरणका लागि कसलाई बढी विश्वास गर्छन ?

b. In your view, whom do you think people rely/trust to respond to and recover from landslides?
यहाँको बिचारमा, मानिसहरुले पहिरो पश्चात, खोज उद्वार र पुनर्स्थापनाका लागि कसलाई बढी विश्वास गर्छन ?

c. Who do you think should be responsible to response to and recover from landslides?
यहाँको विचारमा, पहिरोको प्रतिकार्य र पुनर्स्थापनाका लागि को बढी जिम्मेवार हुन पर्छ ?

4. What is the relationship between locals and elected representatives? Has the relationship change over time? If yes, how?
यहाँको विचारमा स्थानीय (तामाङ समुदायका मानिसहरुले) र स्थानीय जनप्रतिनिधिहरु बिचको सम्बन्ध कस्तो छ ? के उनीहरु बिचको सम्बन्ध समयक्रम अनुसार परिवर्तन भई रहेको छ ? छ भने, कस्तो परिवर्तन आएको छ ?

5. What sorts of interventions, in general, do local governments and external actors support/fund to reduce landslide risks and damages at local levels?
स्थानीय सरकार र अन्य वाह्य निकायले स्थानीय तहमा पहिरोको जोखिम र क्षति घटाउन प्राय जस्तो कस्ता खालका गतिविधिहरु संचालन गर्ने गरेका छन् ?

a. What are the strengths and weaknesses of those measures?

ती उपायहरुको सबल र दुर्बल पक्षहरु के के हुन् ?

b. How are different social groups (including people of different age, gender, ethnicity, livelihood groups etc) engaged in determining, planning and/or implementing those actions?
ती उपायहरुको निर्धारण, योजना तर्जुमा, र/वा कार्यन्वयनमा विभिन्न सामाजिक समुहहरु (विभिन्न उमेरका, लिङ्गका, जात-जातिका, जीविकोपार्जन समुहका मानिसहरु) कसरी सरिक हुने गरेका वा गराइएका छन् ?

c. Are there some people or groups, who in general, either influence local decision-making or act as the link between local people and local government? If yes, who are they and what are their roles like?
के समुदायमा (तामाङ समुदायमा) स्थानीय निर्णय प्रक्रियालाई प्रभावित गर्न सक्ने वा स्थानीय मानिसहरु र स्थानीय सरकार बीच पुलको काम गर्ने कोहि व्यक्ति वा समूह छन्/हुन्छन त ? यदि छन् भने, समुदायमा प्राय कसले त्यस्तो भूमिका निर्वाह गर्ने गर्छ ?

6. Do you think the external agencies and local governments have done enough to involve the people at risk in planning and implementing landslide risk reduction strategies?
यहाँको विचारमा वाह्य निकाय र स्थानीय सरकारले स्थानीय संकटासन्न व्यक्तिहरुलाई पहिरोको जोखिम न्यूनीकरणका रणनीतिहरु तर्जुमा र कार्यन्वयन गर्न पर्याप्त प्रयासहरु गरेका छन् त ?

a. What are the best practices and major barriers to participations?
यहाँको अनुभवका आधारमा स्थानीय सहभागिताका उत्तम अभ्यासहरु र वाधाहरु के के हुन् ?

7. There have been recent changes in policies and institutional framework. What differences have the recent change in policies and institutional framework (including local level elections) brought in development planning as well as planning and implementing landslide risk reduction measures at settlement, wards and rural/urban municipalities' level?
बितेका केहि वर्षमा नेपालमा विपदसंग सम्बन्धित थुप्रै नीति-नियमहरु तथा संस्थागत संरचनामा परिवर्तन आएको छ। यहाँको बिचारमा यी परिवर्तनले स्थानीय (बस्ती, वडा, र ग्रामिण/नगरपालिका स्तरिय) विकास योजना तर्जुमा संग संगै पहिरो/विपद जोखिम न्यूनीकरण योजना तर्जुमा र कार्यन्वयन प्रक्रियामा के कस्तो परिवर्तन ल्याएको छ ?

a. Follow up: How have these changes brought the changes in the budgetary allocation and utilization in the sector of landslide/disaster risk reduction at local levels?
यी परिवर्तनले स्थानीय स्तरमा पहिरो/विपद जोखिम न्यूनीकरणका लागि वजेट छुट्याउने र प्रयोग गर्ने प्रक्रिया र शैलीमा कस्तो परिवर्तन ल्याएको महसुस गर्नु हुन्छ ?

8. How have these changes (elections, federal devolution and decentralization) influenced the participation and empowerment of local communities on landslide risk reduction planning and implementation?

स्थानीय चुनाव, संघीयता, र विकेन्द्रीकरण तथा विपद सम्बन्धी नयाँ ऐन, नयाँ स्थानीय सरकार संचालन ऐन लगायतका परिवर्तनले स्थानीय समुदायको पहिरो जोखिम न्यूनीकरण योजना तर्जुमा र कार्यन्वयन प्रक्रियामा सहभागीता र सशक्तिकरणको लागि कस्तो भूमिका खेलेको छ ?

9. How are these changes and other external forces (such as migration, advancement in information technologies etc.) influencing local knowledge and practices on reducing landslide risks?

यी परिवर्तनहरु र वसाई-सराई, सूचना-प्रविधिमा विकास लगायतका अन्य तत्वहरुले पहिरोको जोखिम घटाउने स्थानीय ज्ञान-सीप तथा अभ्यासहरुमा कस्तो प्रभाव पारेको छ ?

10. In your view, does the local administration have the capacity to deal with landslides? How could this be improved?

यहाँको विचारमा के स्थानीय निकायसंग पहिरोको जोखिम न्यूनीकरण र सामना गर्न पर्याप्त क्षमता छ ? यदि छैन भने त्यो क्षमता कसरी बढाउन सकिएला ?

11. Experience shows that the CBLRR efforts funded by external agencies fade after the end of the projects. What might be useful to address this issue?

विगतका अनुभवका आधारमा दात्री निकायको आर्थिक सहयोगमा संचालित समुदायमा आधारित पहिरो जोखिम न्यूनीकरणका प्रयासहरु परियोजनाको समाप्ति पश्चात बिस्तारै हराउदै वा लोप हुदै जान्छन। त्यस्ता परियोजनाका गतिविधिहरुको दिगोपनका लागि के गर्न सकिएला ?

E) Additional questions

थप प्रश्नहरु

1. Is there anything else you would like to tell me or ask me?

के तपाई मलाई अन्य केहि कुरा सोध्न वा भन्न चाहनु हुन्छ ?

2. Is there anyone you think might be relevant to talk to?

यहाँको विचारमा यस बिषयमा कुरा गर्न सकिने अन्य कोहि सम्पर्क व्यक्ति कोहि हुनुहुन्छ ?

Appendix 5: List of studies reviewed for assessing self-driven approaches to landslide risk reduction

Table A: List of studies reviewed for assessing self-driven approaches to landslide risk reduction

Study (authors/Year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Ali et al. (2017)	Mismanagement of irrigation water and landslips in Yourjogh, Pakistan	Mountain Research and Development	Yourjogh/Garam Chashma Valley/Chitral District/Khyber-Pakhtunkhwa Province/Pakistan
Bjønness (1986)	Mountain Hazard perception and risk-avoiding strategies among the Sherpas of Khumbu Himal, Nepal	Mountain Research and Development	Khumbu Himal
Blaikie & Coppard (1998)	Environmental Change and Livelihood Diversification in Nepal: Where is the Problem?	Himalayan Research Bulletin	Likhu Khola catchment, Nepal
Campbell (2013)	Animals behaving badly	Book Chapter: Living Between Juniper and Palm: Nature, Culture, and Power in the Himalayas	Rasuwa, Nepal
Cieslik et al. (2019)	Building Resilience to Chronic landslide hazard through citizen science	Frontiers in Earth Science	Bajhang and Bajura/Nepal
Dasanayaka & Matsuda (2019)	A study on local knowledge in adaptation to landslide disasters in Sri Lanka	Engineering Journal	Etanwala Village, Matale District, Sri Lanka
Dasanayaka & Matsuda (2022)	Consensus of local knowledge on landslide hazard in depopulated mountain communities in Japan: A case study on Matsunoyama Village	Journal of Integrated Disaster Risk Management	Matsunoyama Village, Japan
Forsyth (1996)	Science, Myth and Knowledge: Testing Himalayan Environmental Degradation in Thailand	Geoforum	Pha Dua Village in Mae Chan district of Chiang Rai Province of Northern Thailand
Gergan (2017)	Living with earthquakes and angry deities at the Himalayan borderlands	Annals of the American Association of Geographers	Gangtok and Dzongu reserve, Sikkim
Gilmour (1988)	Not Seeing the Trees for the Forest: A Re-Appraisal of the Deforestation Crisis in Two Hill Districts of Nepal	Mountain Research and Development	Kabhre Palanchok and Sindhupalchok, Nepal

Study (authors/Year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Gurung (1989)	Human Perception of Mountain Hazards in the Kakani-Kathmandu Area: Experiences from the Middle Mountains of Nepal	Mountain Research and Development	Kakani/Nepal
Hidayati & Noviana (2018)	Non-structural measures for landslide (creeping type) in Selili Hill Samarinda	AIP Conference Proceedings	Selili Village, Indonesia
Huang et al. (2020)	Risk perception and management of debris flow hazards in the Upper Salween valley region: Implications for disaster risk reduction in marginalized mountain communities	International Journal of Disaster Risk Reduction	Upper Salween Valley Region, China
Ives & Messerli (1981)	Repeat photography of debris flows and agricultural terraces in the middle mountains, Nepal	Mountain Research and Development	Kakani, Nuwakot, Nepal
Ives (1987)	Mountain Hazards mapping in Nepal: Introduction to an applied mountain research project	Mountain Research and Development	Khumbu Himal, Kakani and Siwalik, Nepal
Ives (2004)	Himalayan Perceptions: Environmental change and the well-being of mountain peoples	Book	Kakani, Nuwakot, Nepal
Jha & Jha (2011)	Traditional Knowledge on Disaster Management: A preliminary study of the Lepcha Community of Sikkim, India	Indian Journal of Traditional Knowledge	Sikkim/India
Johnson et al. (1982)	Environmental knowledge and response to natural hazards in mountainous Nepal	Mountain Research and Development	Kakani/Nepal
Klimeš et al. (2019)	Community participation in landslide risk reduction: a case history from Central Andes, Peru	landslides	Rampac Grande of Peruvian Andes
Lennartz (2013)	Constructing Roads—Constructing Risks? Settlement Decisions in View of Landslide Risk and Economic Opportunities in Western Nepal	Mountain Research and Development	Dhaune/Rukum
March (2002)	"If Each Comes Halfway": Meeting Tamang Women in Nepal	Book	Rasuwa, Nepal
McWilliam et al. (2020)	Disaster Risk Reduction, modern science and local knowledge: Perspectives from Timor-Leste	International Journal of Disaster Risk Reduction	Lalcho and Caraulun Catchments, Timor Leste

Study (authors/Year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Mendonca & Gullo (2020)	Landslide risk perception survey in Angra dos Reis (Rio de Janeiro, southeastern Brazil): A contribution to support planning of non-structural measures	Land Use Policy	Morro do Abel, Morro da Carioca and Morro Santo Antônio of Angra dos Reis of Rio de Janeiro
Nakileza et al. (2017)	Enhancing resilience to landslide disaster risks through rehabilitation of slide scars by local communities in Mt Elgon, Uganda	Jàmbá: Journal of Disaster Risk Studies	Mt. Elgon, Bushika Subcounty, Manafwa district, Uganda
Oven & Rigg (2015)	The best of intentions? Managing disasters and constructions of risk and vulnerability in Asia	Asian Journal of social science	UBK/Sindhupalchok and Phang Nga provinceThailand
Oven et al. (2008)	Landscape, livelihoods and risk: A study of community vulnerability to landslide events in Central Nepal	Book: Climate Change and Disaster Impact Reduction	Upper Bhote Koshi Valley/Sindhupalchok
Pilgrim (1999)	Landslides, Risk and Decision-making in Kinnaur District: Bridging the Gap between Science and Public Opinion	Disasters	Kinnaur District/Himachal Pradesh
Purworini et al. (2020)	Why is evacuation so difficult? Sociocultural aspects of landslide disaster in Ponorogo, Indonesia	Disaster Prevention and Management	Ponorogo, Indonesia
Rautela & Karki (2015a)	Traditional Practices for Survival in Resource Depleted Himalayan Region: Challenges Put Forth by Climate Change and Response of Local Communities	International Journal of Science and Technology	Uttarakhand, India
Rautela & Karki (2015b)	Weather Forecasting: Traditional Knowledge of the People of Uttarakhand Himalaya	Journal of Geography, Environment and Earth Science International	Uttarakhand, India
Rautela (2005)	Indigenous technical knowledge inputs for effective disaster management in the fragile Himalayan ecosystem	Disaster Prevention and Management	Uttarakhand, India
Rautela (2015)	Traditional practices of the people of Uttarakhand Himalaya in India and relevance of these in disaster risk reduction in present times	International Journal of Disaster Risk Reduction	Uttarakhand, India
Rautela (2020)	Unravelled: Risk reduction genius of the people of Uttarakhand	Book	Uttarakhand, India
Ripert (2009)	Parcelling of Land, Privatisation along with Collective Management of Space and Resources on the Salme Mountainside	Reading Himalayan Landscapes Over time	Salme, Nuwakot

Study (authors/Year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Ritu (2020)	Living with and responding to risk in the Uttarakhand Himalayas: A call for prioritizing lived experiences in research policy praxis	International Journal of Disaster Risk Reduction	Uttarakhand, India
Smadja (2009)	A Reading of the Salme Tamangs' Territory and Landscape	Reading Himalayan Landscapes Over time	Salme, Nuwakot
Sudmeier-Rieux et al. (2012)	A case study of coping strategies and landslides in two villages of Central-Eastern Nepal	Applied Geography	Suspa VDC and Gairimudi VDC/Dolakha
Suri (2018)	Understanding historical, cultural and religious frameworks of mountain communities and disasters in Nubra valley of Ladakh	International Journal of Disaster Risk Reduction	Nubra Valley/ladakh/India
Suwarno et al. (2022)	The Existence of Indigenous Knowledge and LocalLandslide Mitigation: A Case Studyof Banyumas People in Gununglurah Village, Central Java, Indonesia.	Sustainability	Gununglurah village, Central Java, Indonesia

Appendix 5.1: Bibliography of studies reviewed for assessing 'self-driven' approaches to landslide risk reduction:

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Appendix 6: List of studies reviewed for assessing 'community-based' approaches to landslide risk reduction

Table B: List of studies reviewed for assessing 'community-based' approaches to landslide risk reduction

Study (authors/year of publication)	**Title of study/publication**	**Journal/Book (if book chapter)**	**Research/Project's Location(s)**
Ahammad (2011)	Constraints of pro-poor climate change adaptation in Chittagong city	Environment and Urbanization	Matijarna, areas around Batali Hill and Lebubagan of Chittagong, Bangladesh
Alcántara-Ayala & Moreno (2016)	Landslide risk perception and communication for disaster risk management in mountain areas of developing countries: a Mexican foretaste	Journal of Mountain Science	Teziutlán, Puebla, Mexico
Anderson & Holcombe (2006)	Sustainable landslide risk reduction in poorer countries	Engineering sustainability	St Lucia/West Indies
Anderson et al. (2008)	Implementing low-cost landslide risk reduction: A pilot study in unplanned housing areas of the Caribbean	Natural Hazards	St. Lucia, West Indies
Anderson et al. (2011)	Reducing landslide risk in communities: Evidence from the Eastern Caribbean	Applied Geography	St Lucia and Dominica with ongoing works in St Vincent and the Grenadines/West Indies
Anderson et al. (2014)	What Are the emerging challenges for community-based landslide risk reduction in developing countries?	Natural Hazards Review	St Lucia/West Indies
Chen et al. (2006)	Integrated Community-Based Disaster Management Program in Taiwan: A case study of Shang-An Village.	Natural Hazards	Shang-An Village/Taiwan
Cieslik et al. (2019)	Building resilience to chronic landslide hazard through citizen science	Frontiers in Earth Science	Sunkuda, Bajhang and Bajedi, Bajura/Nepal
Claghorn & Werthmann (2015)	Shifting ground: Landslide risk mitigation through community-based landscape interventions	Journal of Landscape Architecture	Medellín, Colombia
Coles & Quintero-Angel (2018)	From silence to resilience: prospects and limitations for incorporating non-expert knowledge into hazard management	Environmental Hazards	Manizales/Colombia

Study (authors/year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Galve et al. (2016)	Cost-based analysis of mitigation measures for shallow-landslide risk reduction strategies	Environmental Geology	Vernazza catchment, Italy
Gumiran et al. (2019)	Participatory capacities and vulnerabilities assessment: Towards the realisation of community-based early warning system for deep-seated landslides	Jàmbá - Journal of Disaster Risk Studies	Five villages of the Philippines
Hermelin & Bedoya (2008)	Community participation in natural risk prevention: Case histories from Colombia	Communicating Environmental Geoscience	Pereira, Manizales and Medellin/Colombia
Hernández-Moreno & Alcántara-Ayala (2017)	Landslide risk perception in Mexico: a research gate into public awareness and knowledge	Landslides	Teziutlán, Puebla, Mexico
Holcombe & Anderson (2010a)	Implementation of Community-Based Landslide Hazard Mitigation Measures: The Role of Stakeholder Engagement in 'Sustainable' Project Scale-Up	Sustainable Development	St Lucia/West Indies
Holcombe & Anderson (2010b)	Tackling landslide risk: Helping land use policy to reflect unplanned housing realities in the Eastern Caribbean	Land Use Policy	St. Lucia, West Indies
Holcombe et al. (2012)	An integrated approach for evaluating the effectiveness of landslide risk reduction in unplanned communities in the Caribbean	Natural Hazards	St Lucia/West Indies
Holcombe et al. (2016)	Urbanisation and landslides: Hazard drivers and better practices	Proceedings of the Institution of Civil Engineers: Civil Engineering	Eastern Caribbean states/Saint Lucia/West Indies
Hostettler et al. (2019)	Community-based landslide risk reduction: a review of a Red Cross soil bioengineering for resilience program in Honduras	Landslides	Olancho/Hondurus
Huang et al. (2020)	Risk perception and management of debris flow hazards in the upper Salween valley region: Implications for disaster risk reduction in marginalized mountain communities	International Journal of Disaster Risk Reduction	Upper Salween Valley Region, China
Jacobs et al. (2019)	The geo-observer network: A proof of concept on participatory sensing of disasters in a remote setting	Science of the Total Environment	Rwenzori region/Uganda
Karnawati et al. (2009)	Strategic program for landslide disaster risk reduction: A lesson learned from Central Java, Indonesia	Disaster Management and Human Health Risk	Central Java/Indonesia

Study (authors/year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Karnawati, Fathani, Ignatius, et al. (2011)	Landslide hazard and community-based risk reduction effort in Karanganyar and the surrounding area, Central Java, Indonesia	Journal of Mountain Science	Karanganyar, Java/Indonesia
Karnawati, Fathani, Wilopo, et al. (2011)	Promoting the hybrid socio-technical approach for effective disaster risk reduction in developing countries	Disaster Management and Human Health Risk II	Karanganyar, Java/Indonesia
Klimeš et al. (2019)	Community participation in landslide risk reduction: a case history from Central Andes, Peru	Landslides	Peruvian Andes (Rampac Grande, Ancash Region)/Peru
Kusratmoko et al. (2017)	Participatory three-dimensional mapping for the preparation of landslide disaster risk reduction program	AIP Conference Proceedings	Cibanteng village, Sukaresmi District, Cianjur Regency/Indonesia
Lempert et al. (2023)	Community-Level, Participatory Co-Design for Landslide Warning with Implications for Climate Services	Sustainability	Sitka Community, Alaska/USA
Liu et al. (2016)	A community-based disaster risk reduction system in Wanzhou, China	International Journal of Disaster Risk Reduction	Wanzhou/China
Malakar (2014)	Community-Based Rainfall Observation for Landslide Monitoring in Western Nepal	Conference Paper	Bhanu VDC, Tanahun, Nepal
Marchezini et al. (2017)	Participatory Early Warning Systems: Youth, citizen Science and Intergenerational Dialogues on Disaster Risk Reduction in Brazil	International Journal of Disaster Risk Science	Cunha and Sao Luis do Paraitinga in Paraitinga watershed in the northeast of Sao Paulo State/Brazil
Mendonca & Valois (2017)	Disaster education for landslide risk reduction: an experience in a public school in Rio de Janeiro State, Brazil	Natural Hazards	A public state school in Nitero´i (Rio de Janeiro State, Brazil)
Murthy et al. (2014)	Capacity building for collecting primary data through crowdsourcing - An example of disaster affected Uttarakhand State (India)	Conference Paper	Uttarakhand State, India
Nakileza et al. (2017)	Enhancing resilience to landslide disaster risks through rehabilitation of slide scars by local communities in Mt Elgon, Uganda	Jàmbá - Journal of Disaster Risk Studies	Mt. Elgon, Bushika Subcounty, Manafwa district, Uganda

Study (authors/year of publication)	**Title of study/publication**	**Journal/Book (if book chapter)**	**Research/Project's Location(s)**
Petterson, Nanayakkara, et al. (2020)	Interconnected geoscience applied to disaster and risk: case study from SECMOL, Ladakh, N. India	Disaster Prevention and Management	Leh, Ladakh, India
Petterson, Wangchuk, et al. (2020)	A multiple natural hazard analysis, SECMOL College region, near Leh, Ladakh, North India, with applications for community-based DRR	Disaster Prevention and Management	Leh, Ladakh, India
Preuner et al. (2017)	A participatory process to develop a landslide warning system: Paradoxes of responsibility sharing in a case study in Upper Austria	Resources	Gmunden/Gschliefgraben in Upper Austria
Raška (2019)	Contextualizing community-based landslide risk reduction: an evolutionary perspective	Landslides	NW Czechia
Ruiz-Cortés & Alcántara-Ayala (2020)	Landslide exposure awareness: a community-based approach towards the engagement of children	Landslides	Ayotzingo and Las Moraledas/Mexico
Ruszczyk et al. (2020)	Empowering Women through Participatory Action Research in Community-Based Disaster Risk Reduction Efforts	International Journal of Disaster Risk Reduction	Bhainse, Bagmati Rural Municipality/Nepal
Schelchen et al. (2017)	Disaster Perception and Ecosystem-based Disaster Risk Reduction in the Mata Atlântica in Brazil	International Journal of Mass Emergencies and Disasters	Teresópolis/Rio De Janeiro/Brazil
Schmidt-Thomé et al. (2018)	Community based landslide risk mitigation in Thailand	Episodes	Thailand
Scolobig et al. (2016)	Compromise not consensus: designing a participatory process for landslide risk mitigation	Natural Hazards	Nocera Inferiore, Southern Italy
Scolobig et al. (2017)	Warning system options for landslide risk: a case study in Upper Austria	Resources	Gmunden/Gschliefgraben in Upper Austria
Suharini et al. (2020)	The role of Community-Based Disaster Preparedness and Response Team in building community resilience	Geografia-Malaysian Journal of Society and Space	Kalipancur Village, Ngaliyan Sub-district, Semarang City, Indonesia
Tappenden (2014)	The district of North Vancouver's landslide management strategy: Role of public involvement for determining tolerable risk and increasing community resilience	Natural Hazards	North Vancouver, British Columbia/Canada
Thapa & Adhikari (2019)	Development of community-based landslide EWS in the earthquake-affected areas of Nepal Himalaya	Journal of Mountain Science	Kalinchowk RM/Dolakha

Study (authors/year of publication)	Title of study/publication	Journal/Book (if book chapter)	Research/Project's Location(s)
Thapa et al. (2023)	Geomorphological analysis and early warning systems for landslide risk mitigation in Nepalese mid-hills	Natural Hazards	Methum, Lalitpur/Nepal
van Aalst et al. (2008)	Community level adaptation to climate change: The potential role of participatory community risk assessment	Global Environmental Change	Linda Vista, Costa Rica
Xu et al. (2012)	Participatory agroforestry development for restoring degraded sloping land in DPR Korea	Agroforestry Systems	Suan County, DPR Korea
Zimmermann & Issa (2009)	Risk-conscious Reconstruction in Pakistan-administered Kashmir: A case study of the Chakhama Valley	Mountain Research and Development	Chakhama Valley, Kashmir/Pakistan

Appendix 6.1: Bibliography of studies reviewed for assessing 'community-based' approaches to landslide risk reduction:

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Appendix 7: List of grey literature reviewed for assessing 'community-based' landslide risk reduction measures

Table C: List of studies reviewed for assessing 'community-based' approaches to landslide risk reduction

Study (authors/organization)	Title of publication	Type of publication
FAO (n.d.-a)	Project highlights Nepal: Building resilience to landslides and the establishment of early warning systems in Nepal	Grey literature
FAO (n.d.-b)	Project Highlights Nepal: Building community-based resilience to landslides through rehabilitation and mitigation actions in Nuwakot District, Nepal	Grey literature
Mercy Corps Nepal (2014)	Piloting monitoring system for Early Warning System (EWS) of Landslides in Far-west Nepal	Grey literature
Mercy Corps Nepal (2016)	Analyzing the effectiveness of moving peg method for landslide monitoring and its potentiality for replication	Grey literature
Practical Action & Mercy Corps Nepal (2012)	Estimating Landslide Probability: A community-based approach for rainfall monitoring	Grey literature
Rural Development Tuki Association (RDTA) (2017)	A Final Report on Investigation and treatment of landslides for recovery and reconstruction of earthquake affected areas of Dolakha, Nepal	Grey literature
Tuki Association Sunkoshi (2017)	A Final Report on Investigation and treatment of landslides for recovery and reconstruction of earthquake affected areas of Sindhupalchowk district, Nepal	Grey literature
UNDP Nepal (2008)	UNDP Nepal Community Based Disaster Management Practices, 2006-2008	Grey literature

Appendix 7.1: Bibliography of grey literature reviewed for assessing 'community-based' landslide risk reduction measures:

FAO. (n.d.-a). Project Highlights Nepal: Building community-based resilience to landslides through rehabilitation and mitigation actions in Nuwakot District, Nepal. https://doi.org/10.1145/1146598.1146637

FAO. (n.d.-b). Project highlights Nepal: Building resilience to landslides and the establishment of early warning systems in Nepal. https://doi.org/10.1145/1146598.1146637

Mercy Corps Nepal. (2014). Piloting monitoring system for Early Warning System (EWS) of Landslides in Far-west Nepal. Lalitpur.

Mercy Corps Nepal. (2016). Analyzing the effectiveness of moving peg method for landslide monitoring and its potentiality for replication. Lalitpur.

Practical Action, & Mercy Corps Nepal. (2012). Estimating Landslide Probability: A community-based approach for rainfall monitoring. Retrieved from https://reliefweb.int/report/nepal/estimating-landslide-probability-community-based-approach-rainfall-monitoring

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Appendix 8: Book chapter in review for inclusion in the *Handbook of the Himalayas*

(Edited by Ben Campbell, Mary Cameron and Tanka B. Subba)

Chapter title: Living with landslides in Sindhupalchok: Mapping local knowledge and strategies in the context of the federal decentralising era in Nepal

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Abstract

This study examines the causes and consequences of 'everyday' landslides for residents in Sindhupalchok, a district heavily affected by the 2015 Gorkha earthquake. Using a political ecology approach, it argues that landslide risks are not only associated with physical aspects like geology or rainfall but also relate to political and socio-economic dimensions. Despite many socio-political transformations in Nepal, residents experience either no or only very little progress in terms of disaster risk reduction. Marginalized groups lack access to decision making and decision makers. Findings highlight that everyday landslides can cumulatively accrue damage comparable to a large-scale event. This study shines a light on local coping and adaptation practices and highlights how they are negatively affected by the changing socio-economic context of rural livelihoods.

1. Introduction

"*Kata dar nalagnu ni, jata tatai siyo ko tuppo jasto ho. Barkhamaa kei bhanna sakinna* (We are so afraid. Everywhere is like the tip of needle. What might happen in the monsoon we dare not say)," shared a 51-year-old man from Sindhupalchok, "Landslides have become so frequent after the 2015 earthquake and haphazard road construction through the village[i]." Based on ethnographic fieldwork conducted between May 2021 and October 2022 in the Tamang village Mathillo Sigarche—a 'category 2' geohazard risk settlement of Nepal's Sindhupalchok District, this study forefronts the day-to-day experience of living with landslides among the Tamangs—one of the largest ethnic minorities in Nepal[ii] (Ghale 2015; Tamang 1992). Although research has highlighted disaster as a function of socio-political processes (Gould, Garcia, and Remes 2016; Oliver-Smith 2016), marginalized groups like Tamangs are often deemed complicit in creating the conditions for their own disaster vulnerabilities (Eckholm 1975; Blaikie 1985; Ives and Messerli 1989). Following a *political ecology* approach (Aboagye 2012; Wescoat Jr. 2015) to explore 'everyday' landslide hazard and risks, the chapter explores the perceived chains of causation and consequence related to landslides. In doing so, this study shifts attention from 'outcome vulnerability' to 'contextual vulnerability' for Disaster Risk Reduction (DRR) policies and practice to be effective (O'Brien et al. 2007; Oven et al. 2019).

The study area is prone to multiple small-scale landslides (< ca. 100 m in length) often not considered sufficiently impactful to warrant attention by donors, government and the media (Ritu 2020; Shrestha and Gaillard 2013). I unpick the ways in which marginalized groups deal with such *silent* or *neglected disasters* (Wisner and Gaillard 2009)(Wisner and Gaillard 2009) to understand a comprehensive picture of the causes and impacts of disaster, particularly where the net impacts of numerous small events take the greatest toll. This chapter begins with the importance of local knowledge in disaster studies, and then introduces the case study location. Subsequent sections outline the findings followed by reflection drawn from this work.

1.1 Local knowledge in disaster risk reduction

The importance of local knowledge (LK) for DRR is widely acknowledged (Hermans et al. 2022; Wang et al. 2019). In Nepal over generations, there has been continuous adaptation to challenges for survival posed by living in the mountain landscape (Ives 2004; Agrawal 1995). In the literature, LK is used interchangeably with terms including indigenous (IK), and traditional (TK) (Dekens 2007; Kelman, Mercer, and Gaillard 2012; Šakić Trogrlić et al. 2022). Integrating LK in DRR is beneficial in adding richness from the local context, supplementing or contrasting with expert or scientific knowledge, helping to articulate local needs, the underlying causes of disaster, and encouraging community participation (Coles and Quintero-Angel 2018; Šakić Trogrlić et al. 2019).

Studies on the synthesis of LK into DRR are increasing (Vasileiou, Barnett, and Fraser 2022) but remain less common in low- to middle- income countries like Nepal (Hadlos, Opdyke, and Hadigheh 2022). Disaster-relevant LK in the context of historically marginalized groups, like the Tamangs, is often overlooked. This chapter explores the rich but underrepresented capacities of the Tamang to live in adverse and unstable conditions, which connect with broader issues of socio-political transformations while living and dealing with disasters.

2. Case study location

Mathillo Sigarche is a Tamang village at ca.1600 masl with around 80 households. Houses are widely distributed across the hillside. The village connects to the Araniko Highway by two major rural roads, but people mostly travel on foot to reach the highway or nearest market due to lack of public transport, but sometimes, get lifts on trucks and lorries. These rural roads experience multiple roadside failures during the monsoon preventing vehicular movement.

Figure 1: Mathillo Sigarche village seen from the top of the village

Maize, millet and wheat are the major crops. Paddy is planted in some lower areas. Agriculture has never been sufficient to sustain the families who have relied on seasonal migration to work in quarrying, road construction, agriculture, and porterage in Kathmandu and nearby Khasa *bazaar* (market area) on the Nepal-China border. Seasonal migration has now largely been supplanted by overseas migration to Gulf countries and Malaysia.

3. Findings from the study

Ethnographic methods were used for data collection (Bryman 2004; Hammersley and Atkinson 2019). The qualitative data analysis software NVivo12 (Lumivero 2017) was used to categorize the findings of my ethnographic work into different themes. The crosscutting theme *'tenants on own land'* will be introduced first, providing the context of the case study. Other themes will be introduced thereafter.

3.1 Tenants on own land

Gorkha conquest dispossessed and reallocated productive lands among Gorkhali soldiers, *jagirdaars* (office bearers) and other clients in the form of *jagir*[iii]*, birta*[iv]*, rajya*[v] and *guthi*[vi] systems (see for examples: Clarke 1979; Regmi 1999; Tamang 2008). State-led strategies pushed ethnic groups such as the Tamangs into marginal lands (Mahat, Griffin, and Shepherd 1986). The imposition of excessive taxes and forced labour worsened their situation (Holmberg et al. 1999) pushing them to take loans from entrepreneurial Brahman and Chhetri families, or merchant Newars, often with exorbitant interest rates (Caplan 1970; Höfer 1979; Tamang 2008). In the study area, many locals recited similar stories of land dispossession from their own experience or oral history from their ancestors.

These stories of losing land to merchant moneylenders correspond to what Rankin (2004) referred to as 'killing the poor'. More than 90% of the people I talked to said their land now belonged to Newar moneylenders, and they now farm as sharecroppers. Borrowing from the merchants was a trap their ancestors could never escape from; interest rates were very high and often the amounts borrowed were manipulated, taking advantage of villagers' illiteracy. They worked hard, spent much time patrolling crops against monkeys and porcupines, but had to carry at least half of the yield to the merchant's house in the nearby *Bazaar*, nearly two hours away by foot. This imposed further stress on the already food insecure Tamangs. Almost all the informants mentioned that the produce remaining after sharing with merchants was inadequate to feed the family for more than a few months. Consequently, for generations they supplemented the diet with cattle rearing, eating wild vegetables, and working seasonally as porters and labourers in agriculture, road construction, hydropower, and stone quarrying.

3.2 Landslide impacts

3.2.1 Deaths, injuries, and psychological impacts

Sita Maya Tamang, who lost her seven natal family members, including her parents, in the fatal 2020 Jambu landslide, laments she is living a cursed life. She shared how her nephew who survived by holding the wires of gabion blocks for a whole night is still in trauma:

> *Everyone is gone. My nephew was unrecognizable when the neighbours rescued him. His body was covered in wounds and mud. Had the helicopter not rescued him to the hospital in time, he might also have died. Seven family members were lost. Not a single body was found, and funerals were performed using dummy bodies. My nephew behaved like a person who lost his mind for several months.*

Sita's case represents an extreme landslide event severe enough to be recorded in official records. Three other families during my fieldwork had at least one member injured or dead due to landslides within the village that were unavailable in the government's database.

3.2.2 Damage to property and disruption of livelihood

It was not surprising that many local families who rebuilt their houses after the 2015 earthquakes on cracked terraces and close to stream channels were later affected by landslides. A seeming "ignorance" of people, however, is not always about absence of knowledge (Pigg 1992). Instead, choices are based on rational comparison of risks, needs, opportunities and available options (Johnson, Olson, and Manandhar 1982; Oven and Rigg 2015).

In the past seven years, three households had to rebuild their houses in other locations due to the repeated incidence of landslides, adding further financial stress. Landslides also badly impact crops and agricultural land. In 2020 and 2021, more than 20 *ropanis*[vii] of land were covered with landslide debris and no compensation from local government and other agencies was received.

Purna Bahadur Tamang shared how he and his family narrowly escaped death in a landslide on 8th July 2020. This was on same day as the Jambu landslide. The landslide completely damaged his single storied tin-roofed part of his home used as a kitchen and for storing grain. It also badly damaged his concrete house and fields above. However, when I visited the village just one year after the incident happened, it felt like it had never happened. His family had re-terraced the fields and recycled the materials from the damaged buildings to add another storey to the concrete house.

3.3 Local knowledge of landslide risks and risk reduction measures

Local people mentioned both supernatural and natural factors as causes of landslides. Most elderly participants and ritual practitioners, like bombos[viii] and lamas[ix], believe that landslides can occur due to the anger of gods and deities (*Yul-lha*[x]), in response to immoral activities, or when people pollute sacred sites.

Whilst the precise descriptions differ, the underlying idea remains similar: elderly people, bombos and lamas generally believe in a 'sentient ecology' (Campbell 2019) of responsive connection with the non-human, such that disasters like landslides and hailstorms, or misfortunes like slipping or being attacked by a leopard, are caused by territorial gods and spirits if people fail to please them through ritual offerings and moral behaviour.

Youths generally held different explanations. They considered that landslides occurred as a combined effect of earthquakes, rainfall, and haphazard road construction. Road construction initiated in 2015 overlapped with the 2015 Gorkha earthquake and was conducted without adequate consultation with locals and environmental protection measures. In these years local level planning and budgeting were largely influenced by ward citizens and not formally transparent. The earthquake triggered landslides on slopes already weakened by excavators:

"Had the dozer not operated in 2016 again, probably the landslide would not have reoccurred. The earthquake and road construction had weakened the slopes." (Male, 28 years)

Some villagers demonstrated clear understanding of the interrelationship between haphazard road construction, earthquakes, rainfall, and surface water triggering landslides. Interlocutors explained that the culvert constructed along the most problematic section of the road was too small for run-off during monsoon and instead acted as a dam. Accumulated water later burst from the road section, and over the adjoining slopes that had been weakened by the road construction and the earthquake. The outburst washed away gabion blocks used for slope stabilization and debris was dumped into streams and across fields and around houses.

3.3.2 Local knowledge on landslide prediction

The appearance of unusual cracks on terraces and on courtyards, the bulging of terrace walls and the (dis)appearances of springs were most mentioned as indicators of landslides. Villagers also mentioned ants carrying eggs, unusual colours and sounds of the water in streams/gullies, tilting of trees/poles, stones falling, sounds of stone falling along gullies/channels, and tightening of doors and windows were also viewed as indicators of impending landslides.

Bir Bahadur, the *bombo*, claimed that he could predict rainfall and possible landslides by hearing the *dhyangro*[xi] sound. According to him, the sound of *dhyangro* feels moist before rainfall as compared to other days. Many participants also considered the darkness and density of clouds as a means to predict rainfall and landslides.

3.3.3 Local early action, and landslide risk reduction strategies

My study found a diversity of early action and risk reduction strategies carried out by the locals to reduce landslide risks and losses, discussed below:

3.3.3.1 Hazard reduction

As discussed by (Oven 2009) in neighbouring Bhotekoshi Rural Municipality, people in my study area engaged in both religious and non-religious actions to manage landslide risks. Terracing, as practiced on most agricultural hillslopes worldwide, was the most common strategy to reduce instability. Locals cut and/or clean drainage channels to manage rainwater away from their farm also to reduce landslide risk. Such activities are generally done annually before and during the early monsoon.

In off seasons people recut bulges, reinforcing with masonry walls. Farmers wait to repair slumps to avoid damage to standing crops. If the slump is small, family members manage it. Otherwise, local labourers are hired to undertake repairs to avoid slumps turning into bigger slides. Similarly, villagers seal cracks and rat-holes by filling them with stones and mud to reduce water percolating.

Farmers also try to prevent landslides by reducing crop intensity and changing the cropping pattern once land is perceived to be at risk of landslides. These strategies included planting maize and millet instead of paddy, or leaving land fallow for months or years when the risk is believed to be higher. Similar strategies were also adopted by the farmers of Nuwakot, a district lying northwest of Kathmandu Valley (Gurung 1989).

When government or external funding is available, locals invest in gabion blocks and tree planting on the sides of the gullies/stream channels to mitigate existing landslides. For example, in 2018 with an NGO's support, residents constructed ca.165 m^3 of gabions on the sides of *Pakhra Khola* channel. The scheme lasted just one year and was washed away in 2020.

Participation in *Bhume Puja* is another hazard reduction strategy. This ritual is performed twice annually—on the full moons of May (Jestha Purnima) and November (Mangsir Purnima)—to appease territorial deities for soil fertility, prosperity, good harvests, and protection of land from bad weather and catastrophes including landslides (Smadja 2009; Soden and Lord 2018). Participation in such rituals also helps to reinforce community relationships—a social capital that could be used in communal activities. When villagers perceive the risk of landslides is increasing, they consult the bombo and lama, and perform a religious ceremony to try to stabilize slopes.

Interestingly, a lama considered the landslide affecting his land was triggered by road construction and would require engineered stabilization, reflecting plural knowledge practices as reported by Bjønness (1986), Pilgrim (1999) and Sherry et al. (2018) amongst others. A bombo, who had mentioned that landslides occur when the territorial deities leave because of sinful actions, claimed that landslides once initiated could not be stabilized because the deity would have already left.

3.3.3.2 Exposure reduction (temporary relocation)

Since the 2015 earthquake, as the monsoon progresses each year, at least 14 households temporarily stay at relatives' homes or on nearby public land in makeshift tarpaulin shelters because of the fear of landslides. Staying in temporary shelters does not remove all risks though as residents must still visit their houses and fields multiple times a day to check on and manage their cattle, assets, and crops/fields. Villagers reported that in households that stay put, a family member stays awake to monitor the gullies, channels, and slopes close by using a torch.

3.3.3.3 Knowledge transfer

Villagers mentioned that knowledge about landslides, early indicators, their history, and ways to reduce hazard and exposure are generally passed on from older to younger family members. Knowledge sharing also takes place informally between extended families, neighbours and peers while grazing, celebrating festivals, rituals, and ceremonies, and in meetings of cooperatives and users' committees. Planting and harvest time is a good opportunity for discussing when villagers work closely together. However, the recent disengagement of younger generations in agriculture, increased outmigration, and the practice of sending children to schools inhibits such IK transfer.

Some informants highlighted that the collective performance of pujas to stabilize slopes helps to inform the wider community about potential landslide risks. The *dhyangro* played during the ceremony not only helps mediation with deities but also acts as an attention-grabbing means of engaging community members. Likewise, the use of prayer flags across unstable slopes after the puja helps to alert people to the sentient ecology. It warns them about landslide vulnerability and encourages people to be cautious while traversing along and interacting with those slopes.

3.3.4 Landslide response, recovery, and reconstruction strategies

Just as the locals were found using various strategies for risk reduction before landslides occur, my study found diverse strategies used to respond to and recover from landslides.

Residents are invariably the first responders to disasters that occurred in Mathillo Sigarche, in the absence of more formal emergency services. Community members help in moving the elderly, persons with disabilities, children, and cattle to safer locations. If someone is trapped by a landslide, residents try to conduct the rescue using simple hand tools (e.g. spade, hoe). People with political connections request support from official rescue teams as required. The locals, particularly young males also help in recovering the dead, and people's valuables from landslides, whilst women tend to spend time supporting affected family members by consoling them and looking after their children and cattle.

3.3.4.2 Ghewa contributing to trauma recovery

For 49 days after a death, the Tamang household undertakes a series of ritual actions called *ghewa* to guide the souls of the deceased towards reincarnation (Soden and Lord 2018). This process involves both paternal clan and maternal clan members, which facilitates the renewal of social bonds in the support of the recovery of mourning family members (Holmberg 1989). Relatives and visitors provide the cash and crops for the family members that is utilized to perform the death rituals and to cope with losses experienced (Tamang 2011). *Ghewa*, as also highlighted in Soden and Lord (2018)'s study, was seen and reported in my research as one of the most important occasions for showing solidarity and care for family members and a way for processing trauma and grief.

3.3.4.3 Repair of trails, roads, and water supplies

Local mobilise voluntarily to repair damaged trails and water supplies quickly after landslides occur. The most intensive repair of roads is done before Dashain (October) after the monsoon. The costs to resume water supplies, such as replacing broken pipes, are divided amongst beneficiary community members. Following repeated impacts on the water supply, residents have recently started using poles to elevate the water pipelines across vulnerable slopes to reduce damage on the pipelines.

Figure 2: Drinking waterpipes elevated to prevent damage from slumps and landslides

3.4 Erosion of Tamangs' Traditional governance system

Traditionally, Tamangs in my study area were governed by their own customary laws and traditional institutions, including the choho (village chief), bombo (shamans/priests), lama (religious leader), and tamba (ritual specialist—historian—poet) (Parajuli et al. 2019). Amongst them, chohos were the village heads whose primary role was to coordinate, regulate and develop the village and society (Tamang 2008).

Chohos regulated the use of forest, pasture and communal land and water resources (Parajuli et al. 2019). According to locals, they ensured the repair and maintenance of trail-paths and drainages through locals' corvee labour, in addition to performance of rituals for territorial deities. This was viewed as ensuring a village's prosperity and avoided disasters. This village institution has been repeatedly undermined by state-imposed governance systems since the Gorkha Conquest, till the present Federal-Republic era. Traditional roles were merged with that of village chief during Panchayat government. However, the choho system completely disappeared in my study area at the start of multi-party democracy in 1990.

Residents claimed the disappearance of the chohos left a leadership vacuum, diminishing communal activities important for reducing landslide risks. Activities like cleaning and repairing drainage were done under the choho's leadership. Instead, today collective efforts are mostly response-focused rather than precautionary. For example, residents still assemble to clear debris and restore trails after a landslide, but proactive cleaning and repairing trials and drainage that could have prevented or mitigated the landslide are rarely undertaken. Most importantly, previously residents commonly migrated seasonally within Nepal, and in some cases to India, returning to the village for labour intensive cropping and harvest seasons, when they would also engage in such communal efforts. With conflict-related overseas migration trends since the 2000s, there is a shortage of workforce to do such essential pre-disaster maintenance work.

4. Discussion

4.1 Local knowledge for landslide risk reduction

The Tamang community of Mathillo Sigarche use a wide range of knowledges to live with landslides. These include oral information about previous events unavailable in official records, alongside both supernatural and natural interpretations of disaster causation, and means to mitigate risks and impacts. The findings illustrate how the impacts of recurring small- to medium-scale landslides may be less visible to *outsiders* but cumulatively can cause significant local impacts (Bull-Kamanga et al. 2003; Shrestha and Gaillard 2013). Coping with recurrent landslides includes occasional injuries and deaths, and repetitive losses of agricultural land, crops, and houses. In food insecure areas such as this, damage to crops and agricultural land seriously impacts livelihoods. A major compounding factor is the disinterest of younger people in agriculture, linked often to outmigration for employment. Consequently, the process of knowledge transfer from older to younger people around everyday risk reduction while cultivating, weeding, and harvesting times is faltering.

Secular and religious measures to reduce landslide risks seem insufficient due to the cumulative impacts of increased landslide incidence particularly after the 2015 Gorkha earthquakes. This situation is compounded by poorly engineered roads, limited drainage management, outmigration of younger people, a lessening of mutual help and labour exchange, and the demise of traditional local leadership such as the choho.

4.2 Continued exclusion in federally decentralized Nepal

Conversations with elderly residents also reflected *nostalgia* (Simpson 2005) for chohos, describing how they would have mediated and facilitated follow-up between the villages and administrative representatives. Concerns are not being addressed. A 75-year-old Tamang, whom I met in 2019 mentioned "Raja le dekhdaina, mato le boldaina" meaning *the king (state) does not see, and the land (that witnesses everything) does not speak.* I met him at a ward office with a petition from his village requesting either to stop ongoing road construction, or to do so by following proper environmental protection measures. His village of 150 households was at risk of landslides from construction. He was instructed to reach out to higher authorities by the ward which would require additional cost, effort, and time. *Gaau gaau maa Singha Durbar* is the slogan of Nepal's federal-republic era, meaning *every village is a power centre* but seems far from reality[xii].

Despite restructuring DRR at local, provincial, and federal levels, there are no visible results for communities like in my study area. Local authorities continue to attribute landslides to a fatalistic combination of heavy rainfall and geology weakened by the 2015 earthquakes, missing the role of poor governance and haphazard development activities. Significantly, damage due to small- and medium-scale landslides were not often officially recorded, rendering them "silent" or "neglected" disasters (Shrestha and Gaillard 2013; Wisner and Gaillard 2009). Decentralization and overlapping roles of DRR are being used to pass on blame by concerned authorities masking inefficiencies and ineffectiveness (Maes et al. 2018). Local representatives claimed that decentralization of roles had not arrived with equally decentralized resources and capacity. Funds at ward level are recurrently spent on post-landslide road clearance, and ad-hoc relief after floods, fire and landslides, mirroring costly response-focused disaster management. DRR professionals at national level are developing guidelines, model laws and training, yet the toll of multiple silent disasters continues to accumulate.

5. Conclusion

In this chapter, I presented a case study of Tamang community dealings with 'everyday' landslides that often escape wider attention. I have shown that the degree of disaster vulnerability is more rooted in historical marginalization and resource extortion, rather than the severity of hazard itself. Villagers use diverse knowledges and strategies to live with 'everyday' landslides, but such strategies are being eroded by increases in the scale and frequency of landslides in recent years, increased outmigration, and the demise of traditional community leadership roles. The study highlighted that small- to medium-scale hazards have the capacity to erode livelihood security and put immense psychological and economic stress on people.

The findings indicate that outmigration to escape the precarity associated with landlessness, deep-rooted poverty, and land and crop losses due to landslides and wild animals' raiding, is doing little to reduce vulnerabilities. Outmigration disrupts knowledge transfer and adds a significant workload on remaining women, children, and elderly.

Devolution of power alone is insufficient if not accompanied with capacity building and accountability mechanisms (Khatri et al. 2022). The study highlighted that the new local government is constrained in their ability to develop and implement DRR strategies. Consequently, despite what are claimed to be progressive policy changes, emphasis in decision making is around infrastructure or roads construction, and post-disaster response and relief distribution, rather than in proactive risk reduction. Strategies should not be merely made based on the numbers of deaths, missing or injured but should be co-produced with affected communities which I suggest is currently absent in DRR plans at both local and national levels. A major adjustment in access to and control of land and resources will be required to address the contexts of vulnerability of indigenous groups like Tamangs.

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Notes

i. Nepal experiences a rapid escalation in rural road construction. Statistics show the growth of rural road network from 2,662 km in 1995 (Bhandari et al., 2012) to 57,632 km in 2016 (DoLIDAR, 2016). The trends are believed to have further increased after the first local level elections in 2017 in nearly two decades.
ii. Government of Nepal (Nepal Reconstruction Authority) had categorised the 2015 Gorkha earthquake affected settlements into three categories: Category 1, 2 and 3. Category 2 refers to households/settlements whose shelters and/or livelihoods are unsafe due to existing state of geohazards, but the risks can be mitigated following appropriate measures.
iii. Land assigned to government employees as emoluments; abolished in 1951.
iv. Land expropriated from local population by the state to allocate to remunerate courtiers on tax-free basis.
v. Land given to the rulers in the defeated principalities by the state during Gorkha conquest.
vi. Land endowed for any religious or charitable purposes.
vii. 1 hectare=19.65 ropanis
viii. Tamang shamanic ritual practitioners
ix. Buddhist priests
x. Territorial deities; Earth divinities
xi. A two-sided drum made of deer/goat skin played by shamans in curing sick people and during festivals and auspicious occasions.
xii. A palace complex in Kathmandu, Nepal's capital, which holds different ministries and government offices. 'Singha Durbar' implies an administrative power centre.

Appendix 9: Types and specification of different sensors used for landslide monitoring

1. 10HS soil moisture sensor

In this study, the 10HS soil moisture sensors were used to measure the relative changes in volumetric water content of the soil. The sensor uses the capacitance-based technique that have low power requirements and consists of two parallel probes that are 10 cm in length (Pradhan, 2021). The sensors have an accuracy of $\pm$ 3% in most soil conditions and provide readings directly in volumetric water content (Onset Brands, 2023e).

Figure A: 10 HS Soil moisture smart sensor (Source: Onset Brands, 2023e) (Date accessed: 06-02-2023)

2. Rain gauge

Rain gauge with tipping bucket mechanism (HOBO S-RGB-M002) were installed for this study. The rain gauge measures rainfall with a resolution of 0.2 mm and 1% accuracy for rainfall rates up to 127 mm per hour (Onset Brands, 2023b).

Figure B: Rain gauge (Picture Source: Onset Brands, 2023b) (Date accessed: 06-02-2023)

3. Temperature (Relative Humidity) sensor

Temperature (Relative Humidity sensor) (S-THC-M002) with accuracy of $\pm$ 0.25^{0}C from -40^0 to 0^{0}C and $\pm$ 0.20^{0}C from 0^0 to 70^{0}C were also installed in this study. The temperature sensors were mounted inside a solar radiation shield (RS3-B) to protect from sunlight and direct splashing (Onset Brands, 2023c, 2023d).

Figure C: Temperature sensor (Picture Source: Onset Brands, 2023c) (Date accessed: 06-02-2023)

Figure D: Solar Radiation shield (Picture Source: Onset Brands, 2023d) (Date accessed: 06-02-2023)

Table 1 summarizes the specifications of the rain gauge, soil moisture and temperature/Relative Humidity sensors used in the study.

Table 1: Specifications of different sensors used in the study (Source: Onset Brands, 2023e, 2023b, 2023c)**:**

Specifications	**10HS soil moisture sensor**	**Rain gauge (HOBO S-RGB-M002)**	**Temperature and Relative Humidity sensor) (S-THC-M002)**
Dimensions	160 x 32 x 2 mm	22.8 cm height x 15.4 cm diameter	45.97 x 11.43 x 10.16 mm
Measurement range	0 to 0.57 m3/m3(Volumetric water content)	0 to 127 mm per hour	Temp: -40°C to 75°C RH: 0-100%
Resolution	0.0008 m3/m3	0.2 mm	Temp: 0.02°C RH: 0.01% RH
Accuracy	+ 0.033 m3/m3(+ 3.3%) for mineral soils	±1.0% at up to 20 mm per hour	Temp: upto ±0.25°C RH: upto ± 5%
Operating temperature	0 to 500C	0 to 500C	-40°C to 75°C

4. HOBO data logger

Remote data logging station (HOBO RX3000) was installed in fields to get instant access to temperature, soil moisture and rainfall data recorded by temperature and soil moisture sensors and rain gauge. The logger has smart sensor connectors that has input jacks to connect 10 smart sensors and can support up to 15 smart sensor data channels as some smart sensors (for example the temperature/RH smart sensor has two channels: one for temperature and one for RH) have more than one data channel. Data from the RX3000 station is transferred at regular connection intervals using a sim card to HOBOlink® web-based software where we can check the latest conditions, view graphs, configure sensors and alarms, set up a dashboard, or download our data. Inside its weatherproof box, the logger has a built-in LCD screen to check the current system configuration and status, start and stop logging, add, and remove smart sensors, and connect to HOBOlink on demand (Onset Brands, 2023a). For power supply necessary to run the logger, a 4 Volt, 10 AHr rechargeable sealed lead-acid battery is fitted inside the box which is charged by a 5-Watt solar panel.

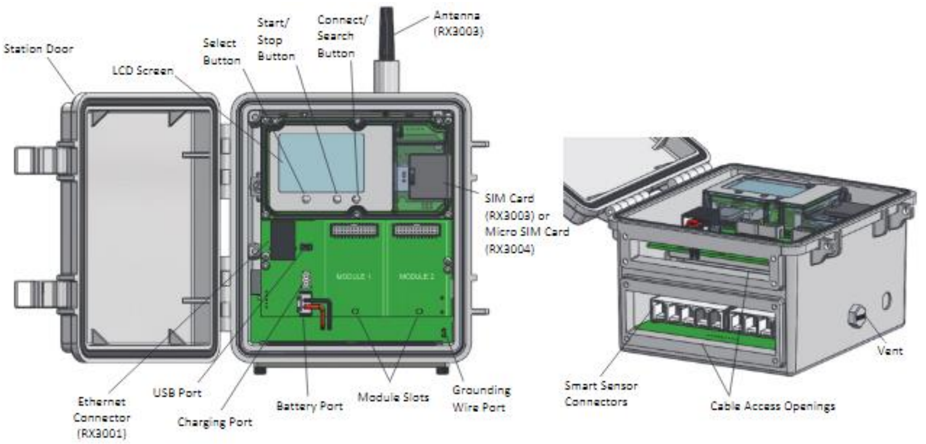

Figure E: Components of Hobo Logger (Picture source: Onset Brands, 2023a) (Date accessed on: 06/02/2023)

5. Acoustic Emission sensor

Geo-Acoustic Aware (GAA) slope monitoring system was installed to monitor acoustic emission stress waves. In this system, the sensor is attached to a GI pipe used as a waveguide in a borehole backfilled with packed coarse sand. The sensor is connected to the GAA2820 data logger for 'near' real-time monitoring of acoustic emission stress waves generated by inter-particle friction. Increases in acoustic emission stress waves indicate accelerating slope movement. The device functions with lithium-thionyl battery. The data is recorded in the form of Ring Down Count (RDC). For downloading data, the data logger can be connected to a host laptop having RST's DT Logger Host Software using a USB cable (RST Instruments, 2019) although with extra costs, the system can be upgraded to telemetric.

Figure E: Acoustic emission sensor and data logger (Picture source: RST Instruments, 2019)

List of citations:

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