Living with landslides: Integrating knowledge for landslide risk reduction in rural Nepal

BASYAL, GOPI,KRISHNA

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Abstract

Nepal is a country highly exposed to the impact of climate change, a situation that is set against the ongoing experience of year-on-year losses from environmental disasters. Of these, landslides result in the highest number of fatalities, a situation that is attributed to a combination of factors: the monsoon climate, the steep unstable topography and a large and often highly vulnerable rural population. Unfortunately, Nepal's experience in this respect is also of global significance: between 2004 and 2016 the country accounted for approximately 10% of all rainfall-triggered landslide fatalities, despite occupying less than 0.1% of the Earth's land area. The majority of these incidents are experienced as a result of relatively small-scale localised landslides, the perennial nature of which means they are often seen as part of life, despite their significant chronic impact on people's livelihoods. This chronic background hazard was then overprinted by the Mw7.8 2015 Gorkha earthquake, which resulted in a significant number of fatalities and had a further devastating impact on people's livelihoods. It also caused additional landslides across Central and Western Nepal. Six years later, these impacts are still being felt. As a result, there is a real need to build greater resilience to landslide risks in rural Nepal; however, efforts to do this lack innovation, and are relatively limited in number and success.

To tackle the problem, this research presents a study of a valley badly hit by the 2015 earthquake where the residents have to live alongside active landslides. The research starts with a household survey to explore the depth of understandings of landslides, the risks they pose and how these features in day-to-day lives. A participatory mapping exercise follows; this seeks to explore in more detail the geographical dimensions of local risk awareness, highlighting several knowledge gaps with regard to why, where and when landslides may occur. Finally, the research presents the development of a novel live demonstration system, which models an actively failing slope to allow participants to gain more insight into the mechanisms of the landslides around them and the risks they pose. Critically, the demonstrator provides a way of visualising and evaluating potential forms of landslide mitigation, such as monitoring or small-scale engineering interventions, that could help to reduce these risks in future. The thesis concludes by considering how this approach might be developed further as a means of reducing landslide risks in rural Nepal.

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Abbreviations

Abbreviations	Meaning
2015 GE	the 2015 Gorkha earthquake
3D	three-dimensional
BIPAD	BIPAD: Building Information Platform Against Disaster, an online national disaster information system, hosted by the Ministry of Home Affairs
BKGP	Bhote Koshi *Gaunpalika* (municipality)
CBO(s)	community-based organisation(s)
CDMC	community disaster (risk) management committee
DesInventar	DesInventar database (disaster inventory/information management system)
DMC	disaster (risk) management committee
DRR	disaster risk reduction
ESD	Earthquake Safety Day (celebrated in Nepal every year since 1999 on 15 or 16 January in memory of the 1934 Great Nepal Bihar Earthquake) (*Bikrami Sambat* 1990 Magh 2)
GHA	Geohazard Assessment, run by the Government of Nepal after the 2015 earthquake
GLOF(s)	glacial lake outburst flood(s)
GoN	Government of Nepal
IHRR	Institute for Hazard, Risk and Resilience (Department of Geography, Durham University)
INGO	international non-governmental organisation
KVERMP	Kathmandu Valley Earthquake Risk Management Project
LRM	landslide risk management
NGO(s)	non-governmental organisation(s)
NRA	National Reconstruction Authority (Established by the Government of Nepal with the main objective of rapid reconstruction of the physical damages caused by the massive earthquakes of April 25 and May 12, 2015, and their aftershocks); the vision of the NRA was 'well-planned resilient settlements and a prosperous society' and its mission was to provide 'leadership for completing reconstruction and resettlement

	with a clear plan maximising the use of local labour, resources and means, and international support'
NSET	National Society for Earthquake Technology – Nepal (NSET – Nepal)
PAR	pressure and release model
PME(s)	participatory mapping exercise(s)
SDG(s)	sustainable development goal(s)
SPSS	statistical software package for the social sciences
UAV	unmanned arial vehicle (drone)
UBK	Upper Bhote Koshi Valley
VDC(s)	village development committee(s) (name of the previous local administrative units that were replaced by the *gaunpalika* (rural municipalities) in March 2017 under the new federal structure)

Everyday terminologies

Terms	Description and other remarks
baari	dryland; *baari* land is formed of gently outward-sloping rain-fed terraces
baadhi-pahiro	combined term; usually describes a debris flow
gaunpalika	rural municipality
ghar-khet	house and farmland, a common Nepali term; it can be used to describe losing everything needed for sustaining a livelihood
ghas-daura	collective term for the collection of fodder and firewood
ghewa-chhewa	birth and death rituals
gumba	monastery
khahare	coarse mix of sand and gravel
khet	irrigated land (*khet* land is a system of horizontal irrigated terraces always used for growing rice, located towards the valley bottom)
khetbari	combined Nepali word denoting wetland and dryland (collectively, farmland)
khola	stream or smaller river
kuleso, kulo	small channel prepared for diverting rainwater, especially in a house yard
pahi, paik, payak	convenient places in terms of everyday use where people go to meet others; despite the distance, they usually head for areas where multiple services are available
pahiro, pairo	a Nepali term to denote a landslide or a debris flow
taar-jaali	gabions (these are wire mesh boxes filled with materials such as stone, concrete, sand or soil and are a common structural method used for slope protection in Nepal; they form a partially flexible block construction used for slope stability and erosion protection, and various types of gabions are used in different engineering scenarios) https://theconstructor.org/geotechnical/gabion-types-uses/24459
tole	smaller (sub-)unit of settlements or a (sub-)unit of a village or a neighbourhood, usually between 5–6 and 10–15 households

Declaration

The work in this thesis is based on research carried out at the Department of Geography, Durham University, England. No part of this thesis has 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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Durham

16.11.21

Dedication

बा-आमा   Ba-Aama

Chapter 1

Introduction

1.1 Introduction

In Nepal, landslides accounted for 42% of the total deaths caused by environmental hazards between 1971 and 2011 (DesInventar Nepal, 2017; Aksha et al., 2018). In line with a globally observed trend, the impact landslides have on Nepal is increasing due to the combined influence of the dynamic geophysical setting and a changing yet still vulnerable rural population (Petley et al., 2007; Oven, 2009; Froude and Petley, 2018). Landslides are mainly experienced as smaller-size events (<5 deaths per event), and they are extensively distributed across the foothills and middle hills region of the country (DesInventar Nepal, 2017; BIPAD Portal, 2021). The impact of these small events, which are often unreported, is greater in sum than the occasional large-scale events that capture the news headlines. These small events also have a significant chronic impact on people's livelihoods (Lewis, 1984; Petley et al., 2007; Oven, 2009; DesInventar Nepal, 2017; Jimee et al., 2019). The recent Mw7.8 2015 Gorkha earthquake (2015 GE) and the subsequent aftershock sequence, resulted in a significant number of fatalities and had a considerable adverse impact on livelihoods in Central and Western Nepal. Research shows that this earthquake triggered about 22,000 new landslides, leaving a notably aggravated landslide hazard in its wake that, in turn, has been exacerbated by subsequent monsoons that have hit the earthquake-damaged landscape (NPC, 2015; Robinson et al., 2017; Roback et al., 2018). This situation of increased hazard and vulnerability during the post-earthquake reconstruction period has considerably increased landslide risk.

Over the last two decades, community-based disaster risk reduction (DRR) initiatives have gained considerable attention worldwide (Gaillard and Mercer, 2012; Jones et al., 2013). Likewise, international agencies and governments have increasingly focused efforts and resources on strengthening community resilience (Šakić Trogrlić et al., 2019; Aksha and Emrich, 2020). It is widely understood that instigating new measures for hazard and risk mitigation that focus on community resilience requires an initial baseline understanding of local knowledge about the risks people face. This is not usually achievable in relatively short-term development projects, and is not typically captured in sufficient nuance and detail in approaches such as vulnerability and capacity assessments. Appraising and analysing baseline community capacity based on surveys of community characteristics to understand how people understand, perceive, and access and utilise risk information, have become increasingly important components of attempts to reduce the impact of geohazards (Haynes et al., 2008). For example, community-based approaches to reducing risk through raising awareness, which are based on better communication, often seek to combine several bottom-up approaches that aim to increase community ownership of risk reduction activities (Oven, 2019). Despite the potential benefits of bottom-up approaches, such initiatives are increasingly being criticised because they are led by outsiders, specifically, non-governmental organisations (NGOs), thereby providing less potential for true community ownership of the process of risk reduction, or for formalising government support for the measures required (Oven et al., 2017). As such, appropriate risk communication tools are vital components for increasing community awareness (Haynes et al., 2008), and need to be developed according to the specific problems posed by the hazards of concern, in this case, landslides. However, development of appropriate tools also has to be undertaken alongside the need not to compartmentalise work on particular hazards, each of which, ultimately, is part of a larger spectrum of competing concerns for householders.

Progress within the field of DRR varies between different hazard contexts. Although significant progress has been made in supporting communities to reduce risk for some hazards, for example, floods, for which the hazard footprint can be forecast and the timing predicted, the same progress has not been made for landslides (Oven et al., 2017). This reflects, at least in part, the fact that landslides are in many ways a more complex hazard to manage (Rosser et al., 2021), yet are often discussed in only general terms with little specific local detail. In a country such as Nepal, landslide risk is widespread, but the local impact, and the pattern, sequence and timing of landslide events are essentially unpredictable, and many sites are concurrently at some degree of risk. Further, the relatively small-scale impact of individual landslides means that these often fall 'under the radar'; therefore, the focus tends to be on reactive rather than proactive approaches. As is the case in many countries, landslide risk management (LRM) initiatives in Nepal are in many ways generic in that they do not vary between events; they follow top-down approaches, remain focused on response (Jones et al., 2013) and are commonly framed as technocratic 'solutions' (Mercer et al., 2008; Oven, 2019). Many initiatives have been criticised for paying lip service to truly participatory methods (Oven et al., 2021) and assuming a one-size-fits-all approach in which standard mitigation methods are transferred between very different hazard contexts (e.g. from floods to landslides). These criticisms suggest that local understandings of landslide risk, including local practices, are often ignored. More widely, in comparison with flooding, the science that underpins landslide hazard and risk has made limited progress in terms of new methods of assessing, analysing and communicating information on landslide risk reduction and making these relevant to the contexts where the impact is most acutely felt. As such, the actual options available to NGOs, communities and government agencies are extremely limited.

Inevitably, improved approaches to landslide risk reduction for communities rely on options that are available locally, and also need to reflect local priorities. Thus, a common starting point is to understand better what people know about natural hazards and risks, and the risks posed by everyday landslide hazards. The beginning of such an understanding can be questions such as the following: What do communities know? How do communities manage risk? What information on the landslide hazard would it be useful to obtain? Here, I use 'community' to refer in general terms to a settlement or village with shared concerns about the hazards it faces (Lee, 2016), or in other words, communities-of-place (O'Neill, 2004).

Without doubt, there is a need for a better community understanding of and engagement in the co-production of landslide science relevant to reducing risk in affected communities and translating it into targeted action. The primary aim of risk communication is to minimise the loss of life and property, or in other words, reduce risk by providing communities with the capacity to recognise warnings and by enhancing people's knowledge so that decision-making with regard to minimising risks can be improved (Slovic, 1986; Pidgeon et al., 1992; Haynes et al., 2007, 2008). Assessing and understanding how landslide risk is perceived and understood by a range of stakeholders, including the public, householders, communities and local authorities, should be the starting point for developing any local landslide DRR initiatives (Haynes et al., 2008).

1.2 Landslide hazard and risk in Nepal

In recent decades, together with an increase in the intensity of geophysical, anthropogenic and socio-cultural factors, the impact of landslides on Nepal has increased (Petley et al., 2007; Oven, 2009; Petley, 2020); arguably, this is reflected by corresponding changes in hazard, exposure and vulnerability. Ninety per cent of annual precipitation falls during the monsoon, and this has an impact on steep and unstable topography that is home to a significant rural population. The phenomenon has been made notably worse as a result of poorly planned development works such as rural road construction. Local roads that are constructed with the aim of enabling development, but often with minimal engineering input across already unstable mountainous terrain, are responsible for a significant increase in the number of new landslides; consequently, despite the roads' intended benefit, they have an adverse impact on local communities (Guzzetti et al., 1999; Oven, 2009; Sudmeier-Rieux et al., 2019; Gurung et al., 2020). Therefore, both natural and human-induced processes contribute to overall landslide risk in rural Nepal. According to disaster data such as that from DesInventar (DesInventar database (disaster inventory/information management system)) (DesInventar Nepal, 2017; Jimee et al., 2019), deaths due to landslides and floods over the long term account for *c*.50% of human lives lost from disasters in Nepal. These disaster events are typically small- and medium-scale occurrences (<5 fatalities), and they are extensively distributed nationwide (DesInventar Nepal, 2017; Aksha et al., 2018). Beyond the known pervasive nature of landslides across the country's middle hills and mountainous regions, there is little detail as to exactly which areas are most at risk and who in those areas; this is a significant barrier to tackling this nationwide problem.

In the Upper Bhote Koshi Valley (UBK), my chosen field area, several high-magnitude landslide occurrences (both single large landslides and events that have triggered multiple landslides) have caused a significant loss of human life and damage to property. A notable recent event, the 2015 GE and its aftershock sequence, triggered extensive coseismic landslides (Robinson et al., 2017; Roback et al., 2018; Williams et al., 2018; Kincey et al., 2020). Monsoon rains have further aggravated the damage caused to the landscape over subsequent years by emerging new landslides and reactivation of existing ones and, consequently, the adverse impact of all this activity has become more severe. The situation is so serious that today (2021, five and a half years after the earthquake), the level of landsliding far exceeds that on the day of the earthquake (Robinson et al., 2017, 2018); as a result, some communities have been destroyed, and farmland has been rendered unworkable. In the 14 districts that were most seriously affected, the Geohazard Assessment (GHA), led by the National Reconstruction Authority (NRA), which was convened by the Government of Nepal (GoN), identified more than 180 settlements as areas that were at such a high level of landslide risk that relocation was deemed the only viable option for a safe future. A further 200 settlements were categorised as needing landslide mitigation measures to reduce the risk to an acceptable level (NRA, 2017a). Of all the districts, the earthquake had the most severe impact on Sindhupalchok District, where about 95% of buildings were destroyed (ReliefWeb, 2015) and the most fatalities of any district during the earthquake occurred, with a large but unquantifiable number being attributed to landslides, reflecting observations from other similar earthquakes (Budimir et al., 2014). Perhaps most startlingly, the 2015 GE was considered to have generated the equivalent of 200 'normal years' of landslides, mostly the rainfall-triggered type (Kincey et al., 2020; Rosser et al., 2021).

The highest rates of loss of life and property in the UBK were in Sindhupalchok District. The valley is the lowest point on the Nepal–China border and hosts the main arterial route, the Arniko Highway, which links Kathmandu to Tibet. In recent years, the valley has seen a string of new hydroelectric power projects. These developments have led to significant settlement in the valley bottom and, in turn, have led to wider development on the walls of the valley alongside the main highway. However, during the earthquake, significant stretches of the highway and several rural roads were destroyed, and have been left in a state of needing constant repair ever since. Unfortunately, the earthquake was not the first disaster; the valley has experienced several major geohazard occurrences over recent decades, including a tragic event on 22 July 1996 in Larcha, also on the Arniko Highway, where a catastrophic debris flow caused by a blockage in the Bhairav Kunda Khola killed 54 people and destroyed 16 out of 22 houses (Adhikari and Koshimizu, 2005). Similarly, the Jure landslide, which occurred on 2 August 2014, killed 156 people, destroyed over 100 houses and closed the Arniko Highway for several days (Oven and Rigg, 2015; Amatya, 2016). On 6 July 2016 (5 July night) more than 77 houses adjacent to the Bhote Koshi river between Larcha and Liping were swept away as a result of a glacial lake outburst flood (GLOF) and associated bank cutting (Amatya, 2016; Cook et al., 2018; Liu et al., 2020). The GLOF caused severe damage along the river, damaging three bridges and destroying the intake dam of the Bhote Koshi Hydroelectric Project (Liu et al., 2020). However, this was not the only event of its type, because there are records of at least four GLOF events since 1935, of which the 1981 event was the most destructive, killing over 200 people in the UBK (Liu et al., 2020). There have been more recent events, for example, the loss of a bridge at Larcha (Fulpingkatti Bridge) over the Bhote Koshi river due to a large landslide on 26 July 2019 (*Kathmandu Post*, 27 July 2019) that punctured the roadbed, leading ultimately to the destruction of the bridge.

Events such as landslides and floods are regular phenomena in the UBK, as they are in other similar valleys in this part of the Himalaya. This high potential for generating disasters poses a significant threat to people and property, which is exacerbated by the proliferation of development projects, particularly in the highly dynamic valley bottom (Adhikari and Koshimizu, 2005; Hasegawa et al., 2009; Cook et al., 2018). Such events also have an impact on the everyday lives of people. For instance, the floods on 6 July 2016 meant that six village development committees (VDCs) (the level of local government equivalent to a parliamentary constituency, and now called a *gaunpalika*) became cut off due to the loss of the road connection. The 26 km Bahrabise–Tatopani section of the Arniko Highway was swept away, making even walking very dangerous. This event also meant that the road to the local market centre at Bahrabise was virtually impassable for several days, interrupting the supply of everyday goods to areas in the north of the valley and also restricting people's access to vital services such as the hospital (MyRepublica, 14 July 2016).

Any successful landslide risk reduction initiative in this context and at the community level, relies on increasing people's understanding of landslides. Many communities maintain 'traditional' ways of managing landslide risk, for example, through appropriate cropping patterns or drainage management. However, there are limits to local capacity for mitigating risks, given the changing landscape and society. This is problematic when landslides are on a scale that makes management highly challenging and are also constantly changing, for example, after the 2015 GE. Structural measures, or physical mitigation, are often based on basic engineering, for example, gabions (stone-filled wire mesh boxes), or bioengineering (crops selected because they stabilise the soil), but these methods are efficient and appropriate only in certain circumstances and often only have value for tackling problems on a local scale (Sudmeier-Rieux et al., 2012; Sudmeier-Rieux et al., 2013; Devkota et al., 2014). Also, inevitably, such approaches are only sustainable when developed alongside other efforts that are based on an understanding of local knowledge and community-led ways of managing risk. In addition, landslides are only one of a range of day-to-day risks faced by communities, and so their impact is constantly weighed against competing needs for very limited resources, such as access to drinking water or education. Where a risk is infrequent, or seasonal, and something that mostly occurs 'elsewhere', it is perhaps not surprising that landslides slip down people's and governments' priorities until an event occurs, at which point it is usually too late.

Identifying appropriate mitigation measures can also be challenging where options are limited, and people's wishes can be unrealistic. For example, a common aspiration is to 'stop' a landslide to eliminate risk, but this may often be impossible or impractical because of the scale of the events in Nepal and the available resources. Similarly, information on hazards and risks is usually inadequate, often being too crude, general or out of date to help inform decision-making:

> Landslides constitute a hazard to life and infrastructure and their risk is mitigated primarily by reducing exposure. This requires information on landslide hazard on a scale that can enable informed decisions.
>
> (Milledge et al., 2019, p. 837)

Despite this, significant resources are invested in managing landslide risk every year, albeit in a piecemeal manner; however, landslides have not yet received sufficient attention and are not treated as an important hazard in the perennial local planning process (Amatya, 2016). Invariably, most attention is paid to high-magnitude hazards, and the everyday ones have been almost ignored, resulting in a cumulative impact on local communities (DesInventar Nepal, 2017). Therefore, an acceptance of risk, and learning to live more safely alongside landslides, may be a more appropriate approach to mitigation.

The issue of landslide risk in Nepal sits within a wider context. The country in general and its rural communities in particular have been undergoing extensive and significant changes associated with politics, economics, migration and development. These types of change have influenced how human activities have generated, adjusted to or managed the risks posed by natural hazards, including landslides (Gurung, 1989). However, this reality has not been discussed adequately in the Nepali context. Moreover, the role played by such changes both before and after high-magnitude events, such as the Jure landslide of 2014 and the 2015 GE, has not been properly investigated, particularly in terms of how they shape people's understanding of risks in 'normal' times. These events may significantly affect people's vulnerabilities, for example, through rapid resettlement after major events, which then shapes understandings of the landslide hazards and risks to which people are exposed (Rosser et al., 2021). This remains a fundamentally geographical problem, and the vital information required to underpin any form of mitigation is the proximity of livelihoods to areas at risk and an accurate assessment of the time at which somewhere becomes risky.

1.3 Rationale behind the research and its aim

> Reducing landslide risk in many mountainous regions is most effectively achieved by reducing exposure to landslides, because landslides cannot be predicted or stopped, and engineering solutions are generally impractical or impossible.
> (Milledge et al., 2018, p. 837)

This research takes an interdisciplinary approach and aims to investigate the local understandings of everyday landslide hazards and risks as perceived by both householders (individual) and communities (collective). I aim to make a valuable contribution to landslide risk reduction by addressing knowledge gaps in relation to landslide hazards and risks, and will seek to develop a means of tackling these gaps using a new physical demonstration tool. In doing so, I use both quantitative and qualitative methods in a mixed approach, whereby each step of the research process moves progressively towards my goal of developing new and innovative approaches to landslide risk reduction. My approach will be to collate current understandings of the problem and explore the links between them, with the aim of gaining a comprehensive insight into local perceptions of landslide hazards and risks. To achieve my aim, I will utilise both community surveys and more interactive exercises.

My research has two main starting points: (a) to understand better how people comprehend the physical aspects of landslide hazards and risks in both a spatial and temporal context in their locality; and (b) to explore novel ways of building on this knowledge to improve communication in relation to landslide hazards and risks. Reflecting on these two key issues, I then intend to develop a physical tool for community-focused demonstrations (the landslide demonstrator), with the aim of exchanging knowledge about landslide hazards and risks (Weichselgartner and Kelman, 2015). My focus is on everyday landslide processes, and I wish to show the physical mechanisms of landslides, their spatial nature and the generation of risk over time, so that together with communities, I can explore how to minimise landslide risk. By challenging the current Nepali focus on a top-down approach and putting the household and community at the centre, this research explores a new risk communication perspective. In doing so, the study will investigate the following research questions:

1. How do householders perceive and respond to landslides following the 2015 GE?
2. How has the understanding and perception of landslide hazards and risks changed over time?
3. What knowledge and capacity do communities have with regard to the management of landslide hazards and risks?

4. How and to what extent do different forms of risk communication support communities to broaden their understanding of landslide hazards and risks with the aim of increasing resilience to landslides?

1.4 Structure of the thesis

The thesis is divided into three sections, spanning seven chapters. The first section presents the conceptual framework that introduces the problem of landslide hazards and risks, and reviews previous research to help define the scope of this research and the basis for the methodology adopted. The second section contains three substantive empirical chapters, which present and analyse the results of the research. The concluding section discusses the results and draws conclusions so that a future direction for research in this field can be determined. In detail, the chapters are as follows:

Chapter 1 introduces the definition of the problem, the context, the aim, the intended contribution of the study, introductory details of the study site and a brief account of the conceptual approach used for the analysis.

Chapter 2 reviews the previous literature on the relevant theoretical and empirical debates about DRR and landslides, and risk communication, and considers their relevance to the Nepali context. This chapter establishes the reason behind the choice of the theoretical framework, which is based on risk perception and the communication of information on hazards and risks in relation to landslides.

Chapter 3 outlines the methodology used in the research, which applies a mixed-methods approach using multiple case studies to provide empirical data. The chapter justifies why the mixed-methods approach is appropriate, considering the research aim and the conceptual framework. The chapter discusses some of the challenges associated with the research strategy and data collection, namely, my positionality, issues with regard to local languages and the emotive questions raised by researching landslide risk and its subsequent representation in my analysis.

Chapter 4 discusses the findings of research questions (1) and (2): 1: How do householders perceive and respond to landslides following the 2015 GE? and 2: How has the understanding and perception of landslide hazards and risks changed over time? Using the results from an extensive household questionnaire survey, this chapter analyses the characteristics of the everyday risk problems faced by householders, the role of landslides in their everyday lives, the impact these have and their understandings of the spatial and temporal characteristics of landslide hazards and risks. Here, I consider how householders exposed to landslide hazards and risks deal with them at a household level and how they anticipate any likely future impact. The data are divided into two categories to facilitate the analysis of off-road and on-road settings, broadly reflecting a wider traditional versus new settlement pattern typical of my study area.

Chapter 5 describes a mapping exercise using focus groups to investigate how people perceive landslide hazards and risks within their wider communities, and specifically discusses research question (3): What knowledge and capacity do communities have with regard to the management of landslide hazards and risks? The chapter explores community awareness of the spatial and temporal aspects of landslide hazards and risks by conducting participatory mapping exercises (PMEs) in two communities.

Chapter 6 describes the development and testing of a new physical demonstration tool for use in communities. I first describe the development of the tool and then consider what messages it could be effective and helpful in delivering when deployed in mountainous Nepali communities. The chapter also presents an analysis of the efficacy of the approach based on audience feedback, including that from villagers, technical specialists and agencies responsible for implementation of risk reduction measures, including the government. The chapter addresses research question (4): How and to what extent do different forms of risk communication support communities to broaden their understanding of landslide hazards and risks with the aim of increasing resilience to landslides?

Chapter 7 contains discussions and my conclusion, and brings together the results from all three empirical chapters to reflect on the research aim. The results show the links between outcomes and associate these with the main purpose of the study. The objective of the chapter is not to make generalisations from the findings of the three empirical chapters, but to discuss the challenges identified (Chapter 4), confirm the suitability of the methodological processes (Chapter 5) and appraise the potential need for continuing this research in the future (Chapter 6), either by replicating or upscaling it, to address any remaining questions.

Chapter 2

Literature review

2.1 Introduction

Research exploring innovative ways of communicating information on landslide hazards and risks is relatively new in relation to Nepal. However, following the 2015 GE, there has been a growing interest in the need for more effective approaches to landslide risk communication and risk reduction. This chapter aims to review and examine the literature on local knowledge and risk perception, and also on approaches to risk communication, highlighting the move away from one-way communication to a more integrated approach that recognises and values different types of knowledge. I focus in particular on the household and 'community' levels. Although I note 'community' can be a problematic concept because of the myriad ways in which this can be defined (see, e.g. Titz et al., 2018), I find it a useful starting point for my work because this is the level at which decisions are often taken. Drawing on Davies et al. (2015), I define community as a settlement or group of households that share a concern about landslide hazards and risks. I begin by reviewing the literature on hazard, vulnerability and risk more generally and situate my research within the vulnerability school of thought that, in turn, is situated within disaster studies.

2.2 Hazard, vulnerability and risk

In a broad and semi-quantitative sense, risk is understood as a function of hazard and vulnerability and is commonly expressed in the form of the equation:

risk = hazard × vulnerability

(Wisner et al., 2004)

Risk is defined as 'the combination of the probability of an event and its negative consequences' (UNISDR, 2009, p. 25). For Wisner et al. (2004), risk is viewed as the outcome of an interaction between two opposing factors, with natural hazards on one side, and the inherent vulnerabilities within communities on the other (Figure 2-1) (Wisner et al., 2004). Critically, risk is not solely environmental or natural in origin (Kelman, 2020). People or things, for example, infrastructure, have to be exposed and vulnerable for risk to manifest.

Building on earlier work by O'Keefe et al. (1976), Wisner et al. (2004) provide an important perspective on the social dimensions of risk. The pressure and release (PAR) model shown in Figure 2-1 was first developed by Blaikie et al. (1994) and later modified by Wisner et al. (2004). It argues that disasters are the outcome of two interacting, opposing forces, these being a natural hazard (e.g. an earthquake or a flood), and social vulnerability; together, they create the risk. This model further examines vulnerability, and highlights how the vulnerable conditions experienced in a given locality, for example, a family living on a steep, landslide-prone slope in Nepal, are the result of wider social, political and economic processes, represented in the PAR model as root causes and dynamic pressures. In this way, the model proposes a progression of vulnerability through three stages, during which large-scale politics and power cannot be separated from the generation of unsafe conditions that lead to risk and disasters experienced at the community and household level.

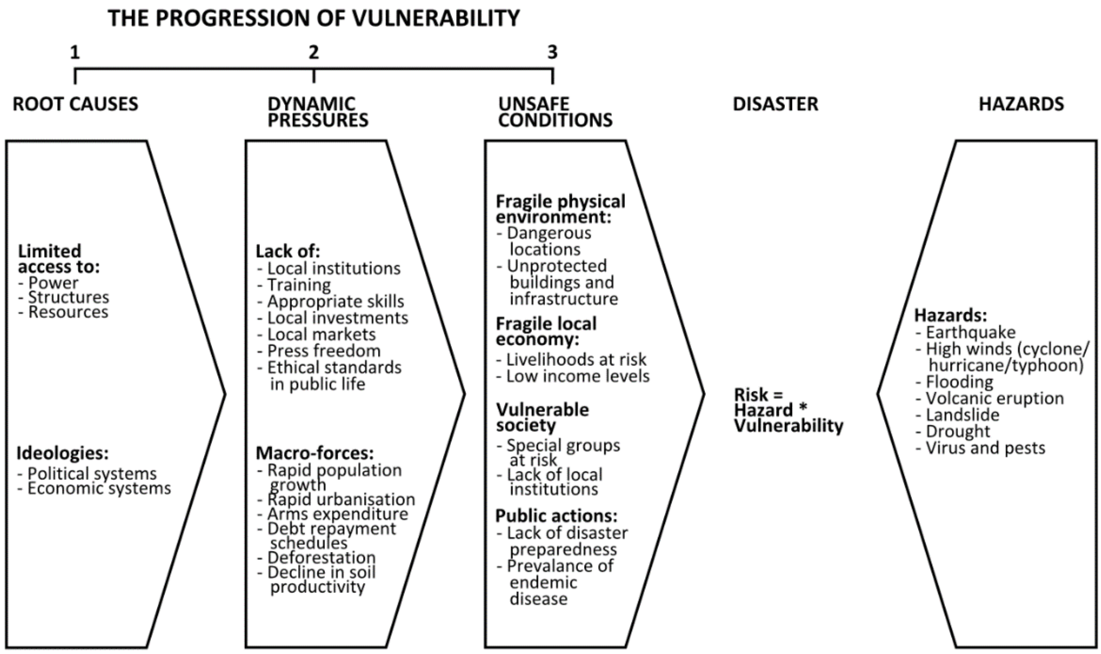


Figure 2-1. The progression of vulnerability in the pressure and release model. (Source: Wisner et al., 2004, p. 51).

A vulnerability approach to understanding disaster risk highlights the social, physical, environmental and economic characteristics such as poverty, caste, gender, education, isolation and lack of market access that could increase or decrease the vulnerability of an individual, household or community (Davies et al., 2015; Rigg et al., 2016). These factors are subject to change over time and across space, making vulnerability highly dynamic (Wisner et al., 2004, 2012; Fell et al., 2008).

Some authors suggest that new forms of vulnerability are prevalent in many communities as a result of wider social, political and economic change. For example, in our study of rural communities in Eastern Nepal (Rigg et al., 2016), we highlight how ‘development’ is changing and reworking vulnerability. We make a distinction between inherited vulnerability, for example, vulnerability associated with caste, ethnicity, gender and the traditional rural way of life that renders certain households vulnerable (Pilgrim, 1999; Oven and Rigg, 2015), and produced precarity, which we define as new forms of vulnerability that result from wider neoliberal development projects, for example, cash crop production, road construction for market access and international migration for employment (McLaughlin and Dietz, 2008; Rigg et al., 2016). Based on the interviews conducted with rural householders, we observed that households were not simply becoming more or less vulnerable over time, but that the very nature of their vulnerability was changing. For example, they were becoming less reliant on their own subsistence agriculture, relying instead on remittance income from family members working overseas. This may reduce the vulnerability of the household in the short term, but it is unclear what it means in the long term (Sunam and McCarthy, 2016). We are also seeing the erosion of traditional ways of governing and organising the community, including mutual help and support (Rigg and Oven, 2015). Similarly, the 2015 GE highlighted the vulnerability of women, children and older people, many of whom were left behind while working-age men sought employment overseas (McLaughlin and Dietz, 2008; Rigg et al., 2016; Tamang 2020). The high level of out-migration has resulted in the neglect of agriculture and, thus, new situations have also created new vulnerabilities and, hence, different pressures on rural life (Rigg et al., 2016).

Likewise, internal migration in the middle hills region of Nepal has led families to move from traditional hillside villages to roadside areas because they offer economic opportunities and support for family livelihoods, including better access to employment, education, healthcare and markets (Lennartz, 2013; Sudmeier-Rieux et al., 2019). Unfortunately, these emerging roadside settlements are commonly found on available flat land by incoming stream channels prone to debris flows, or at the bottom of steep slopes prone to rock falls (Oven, 2009; Sudmeier-Rieux et al., 2012). In addition, the construction of poorly engineered roads, which can themselves lead to landslides, and the migration of people to homes alongside them, can increase exposure to landslide hazards (Petley et al., 2007; Froude and Petley, 2018). This exposure can be confounded by the absence of local or inherited knowledge of the new risk environment (Oven, 2009).

The 2015 GE saw many households displaced due to landslides and others living with an unknown or uncertain level of risk (Rosser et al., 2021). The connection between hazards and the living environment of the population needs to be understood. As Reiger (2021) highlights in her study of multi-hazard risk in rural Nepal, there is a need to consider not only the landslides triggered by the earthquake and the risks these pose, but also the increasing risk of landslides as a result of haphazard development activity such as road construction, and how all of these risks are balanced in relation to the everyday risks faced by rural householders.

2.3 Local understandings and perceptions of landslide hazards and risks

Risk perception has a significant influence on vulnerability, because vulnerability is considered to be the function of three factors (Alexander, 1991, 1992), as shown below:

$$\text{Total vulnerability} = \text{Risk amplification measures} - \text{Risk mitigation measures} \pm \text{Risk perception factors}$$

In this equation, the role of risk and how it is perceived is a significant factor in determining household and community vulnerability (Alexander, 1991, 1992). Risk perception is also an important consideration when developing and implementing DRR initiatives (Gurung, 1989; Calvello et al., 2016). Risk perception is concerned with people's own subjective judgements about the hazards and risks they face, in this case, in relation to landslides, and following on from this, the degree to which landslides feature in the everyday decision-making of the individual and the community (Haynes et al., 2008; Lee, 2009; Crozier and Glade, 2012). In this regard, risk perception, which is shaped by knowledge, is seen as the starting point for developing achievable and appropriate interventions for DRR (Slovic, 1987; Pilgrim, 1999; Sou, 2014; Calvello, 2017), with the community themselves identifying their own needs, making plans and undertaking actions to reduce the risks faced (Solana and Kilburn, 2003). More widely, several earlier studies have been undertaken to assess local knowledge and risk perceptions at the community level, and I have summarised these in Table 2-1. These studies cover a range of hazards, for example, volcanoes (Paton et al., 2000, 2008; Stone et al., 2014; Eiser et al., 2015), earthquakes (Edgar and Jackson, 1981; Armaş, 2006, 2008) and floods (Grothmann and Reusswig, 2006; Whitmarsh, 2008), in a range of cultural and interdisciplinary contexts (Bankoff, 2003; Krüger et al., 2015; Hernández-Moreno and Alcántara-Ayala, 2017). Comparatively few studies have been undertaken on landslides specifically. Two exceptions are a study by Roder et al. (2016), which explored local perceptions of landslide risk in Taiwan, and another undertaken in India by Pilgrim (1999), who found strong ties between an indigenous community and the natural environment, along with powerful memories of past disasters, which shaped the people's perception of future risk. These findings demonstrate the importance of social, cultural and interdisciplinary approaches to understanding risk. Some studies have explored how risk perceptions vary spatially (Haynes et al., 2007). Problems associated with location, or location-specific hazards and risks, are often based on people's direct experiences, knowledge and consequences for their everyday lives. However, knowledge gaps were noted, for example, among new immigrant families, who do not have experiential or inherited knowledge (Niewöhner et al., 2004; Birkholz et al., 2014).

'Local understandings' of risk are a complex concept to finely delineate, with many overlaps with 'risk perception'. Assessing 'local understandings' in the context of protective action in community-level risk reduction is important (Sullivan-Wiley and Gianotti, 2017). For effective mitigation measures taken by householders or communities (Lujala et al., 2015), local understandings provide insights into what might be deemed appropriate (Sullivan-Wiley and Gianotti, 2017). Previous studies show that local understandings include a richness of knowledge on local hazards and risks. Experiences are expressed via local vocabularies, knowledge of the local landscape, local practices, and conceptualisation of the causes, consequences, and anticipation of hazardous process. Such local understandings can be the first step in discussions about local hazards and risks where the starting point can be otherwise intangible or abstractive from people's everyday lives. For example, in conversations aorund disaster impacts when no recent disaster has occurred, individual or collective responsive actioncan be challenging to explore, so understandings provide a valuable entry point (Wilkinson et al., 2020). Local understandings are inevitably influenced by the socio-economic and demographic characteristics, the nature of hazards that people live with, all of which shape direct and indirect experiences (framed in Figure 7.1) Critically, exploring these understanding gives a more nuanced idea of how peoples experiences have evolved and how they emerge over the time.

Table 2-1. A review of relevant risk perception studies within the academic literature for conceptualising the research in a broader sense

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
(Alexander, 1992) Defining hazards risk conceptually. How risk and vulnerabilities are associated with hazard area.	Peru and Italy. Concerning slope instability and human intervention in landslide hazards. KW: human intervention	Qualitative and observation methods.	Determining landslide risk perception is more about the attitude of local people towards reducing their vulnerabilities. The study compares two communities, and includes an examination of how human activity has caused an increase in hazards risk. Risk perception is influenced by economic circumstances.	The dichotomy between the risk perception of local farmers who ignored the problem and that of the theorists or experts who perceived the problem but misunderstood the solution.
(Calvello et al., 2016) Aims to assess issues with regard to landslide hazard risk knowledge, perception and opinions among a community in an area of Italy on which landslides have had a significant impact.	Case study, Italy. This case study focuses on a non-structural aspect of risk management according to the perception of landslide risk by communities. KW: risk perception, landslide, communication, education, community, resilience	Quantitative survey. Face-to-face interviews utilising different response scales. Yes/No/Don't know categories, 10-point Likert scales and multiple choice and open questions, etc. were employed.	Lack of solid public programmes focusing on awareness and knowledge even in areas seriously affected by landslide disasters. However, a substantial amount of public funds were invested after a high-magnitude landslide in 1990. This study focused on knowledge about, perceptions of and opinions on risk, risk management and interventions. In addition, the study found that it is essential for the relevant administration to understand public perception and opinions to implement landslide risk management measures effectively, further suggesting community participation is a key factor in landslide risk management.	This study finds most projects do not discuss the efficacy of projects that are implemented in communities, despite substantial investment after high-magnitude events. The changing pattern of risk perception is not evaluated. Recommends the need to generate more hazard information to support effective risk mitigation strategies at the community level.

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
(Dahal and Hagelman, 2011) Risk perception study in the mountainous region of Nepal focusing on a glacial lake outburst flood hazard.	Nepal, about a glacial lake outburst flood hazard after a major occurrence. A case study focusing on two villages. KW: glacial lake outburst flood, risk perception	Quantitative and qualitative surveys, field observation, semi-structured interviews. In the process of data collection, opinions were also obtained from residents, local leaders, teachers, the staff of local offices and workers from non-governmental organisations.	All respondents were aware of the existence of the Tsho Rolpa glacial lake, but most said they were not scared of the potential for outburst flooding. Only a small percentage were worried about a hazard source in the area where they lived. Public trust was found to be a key factor. The study found a negative correlation between public trust and risk perception; trust is important because information dissemination alone is unlikely to work. More people are moving into the area even closer to the river channel (tourism potential). Moving closer to the hazard source is motivated by the economic opportunities available. Paper makes the case for a scientific assessment of the potential for future glacial lake outburst flood hazards.	Reliable warnings needed. Repeated false warning were negatively affecting public trust.
(Hernández-Moreno and Alcántara-Ayala, 2017) Analyses landslide risk perception and public awareness and knowledge following a landslide event.	Mexico, two communities. One community has no landslide experience, and another has directly experienced a landslide in the past. KW: landslides, risk perception, risk awareness, knowledge, disaster risk reduction	Questionnaire survey was carried out at two case study sites. Seven aspects related to landslide risk perception considered: experience, landslide risk awareness, exposure, preparedness, responsibility, response and trust.	Landslide risk perception associated with experience, public awareness and knowledge. The study found that the two communities perceived the risks associated with landslides differently. It is important to consider public trust in any disaster risk management initiatives at the local level.	Public trust should be an integral part of disaster risk reduction at the local level, and should be determined in detail before making plans and implementing any programmes.

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
(Ho et al., 2008) Aims to examine how risk perception is influenced by the type of disaster (flood and landslide) and victim characteristics.	Taiwan 2004. Carried out in a post-disaster context, and considers the year in which many towns were severely affected by floods and landslides, resulting in a large number of fatalities and huge economic losses.	Survey undertaken with victims and the public. Quantitative methods: multiple regression analysis. Rural and urban contexts analysed.	Study attempts a comparison between the National Risk Perception Survey and local risk perception in communities. Several demographic characteristics and the relationships between them, for example, gender and education, were assessed. A higher level of education was linked with a higher level of risk perception. Gender plays a significant role in risk perception.	Suggests further investigation into the psychological dimension of victims' attitudes towards risk. Identifies research gaps with regard to the consequences of hazard occurrence and how these vary between different communities and households.
(Kellens et al., 2013) Review paper, assessing flood risk perception and communication in published literature.	In the context of the increasing interest in studying flood risk perception and management. KW: flood risk, literature review, risk communication, risk perception	Online literature search using appropriate search criteria analysed 57 peer-reviewed articles from peer-reviewed papers covering 22 countries. Quantitative categorisation of the literature.	Risk perception and communication has gained increasing interest and attention in the area of flood risk management.	Identifies the complete absence of true risk communication research; therefore, it suggests further research.
(Le Coz et al., 2016) Flood risk reduction from the citizen science perspective.	KW: citizen science, floods	A short article exploring the importance of clear local initiatives and the selection of proper tools suitable for data collection and	The study found that collecting data locally was positively related to encouraging communities to undertake local initiatives. Information/data collected through local initiatives, that is, a citizen science approach in collaboration with local stakeholders, proved extremely valuable for raising	

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
		processing, and of supporting planning at a local level.	public awareness of natural hazards and inspiring local action. Trust is important.	
(Maes et al., 2017) Review paper.	Literature reviews on landslide risk reduction measures in the context of the global south. KW: mass movements, disaster risk reduction, resilience, mitigation, global south	Literature review covers studies in peer-reviewed journals from 99 tropical counties on landslide risk reduction.	Focuses on challenges faced in these countries. Summary of landslide risk reduction initiatives, and categorisation measures taken.	
(Oven, 2009) Community vulnerability to landslides, and risk perception.	Case studies in Upper Bhote Koshi Valley, Central Nepal. KW: resilience, disaster risk reduction, landslide, Nepal	Qualitative (primarily) and quantitative. PhD thesis. Interviews, household surveys, community mapping, etc.	Changing settlement patterns associated with road construction were changing patterns of landslide exposure and vulnerability. A high level of awareness of landslide hazards and risks was noted, but gaps in knowledge were also observed, especially when people were exposed to new or low-frequency hazards. Landslide risk was a lower priority concern than other more pressing everyday risks, for example, access to a reliable water supply, healthcare, school. Participants were found to hold different world views in terms of the causes of landslide hazards and risk (i.e. scientific and supranatural).	The study focused on one period of time before the 2015 earthquake. How have risk perceptions changed over time?
(Paton et al., 2008)	Volcanic hazard.	Re-surveying the same respondents (*n*=202)	People's own assessment of risk and, thus, their decision-making in relation to taking precautions, is based on the	Future work should address how to increase the amount of variance in intention to

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
Assess the comment that 'people's interpretation of their experience of volcanic hazards and public volcanic hazard education programmes influences their risk perception' (p. 179).	How direct experience of hazard interaction increases local people's risk perception. Before and after ash fall from the 1995 eruption of the Mount Ruapehu volcano in New Zealand.	who took part in the initial survey. How experiencing the consequences of a volcanic hazard affects risk perception and preparedness	cost-benefit aspect of the proposed mitigation, as perceived by them. It was observed from the analysis that a negative outcome expectancy (personal actions are futile in the face of such a destructive hazard) had a negative relationship with community participation, that is, people holding such a belief would be significantly less likely to discuss the volcanic hazard issue with other community members. Interestingly, educating the public may not motivate people to manage their risk.	prepare that the model can accommodate because it was tested within a limited context.
(Pilgrim, 1999) Aims to investigate the level of risk acceptable to a community and looks at existing strategies for disaster risk reduction.	Himachal India. Assessed 'acceptable risk' and existing strategy for disaster risk reduction in the district in the context of road construction and landslides. In Sapni, a major landslide destroyed the link between the village and the rest of the area. Later, the village campaigned for the reconstruction of the road to re-establish the connection. KW: landslides, Indian Himalaya, transport, local	Qualitative approach (participant observation and informal discussions). Formal interviews were conducted with government officials.	The research asserts that 'village-level decision-making institutions are an important feature in the process of finding an acceptable balance between meeting immediate needs and assuaging concerns over mountain hazards' (p. 63). More tangible needs dictate the risk perception (p. 63) and disaster protection is a low priority (p. 63); public recognition of any initiative is itself a key factor in any successful intervention. At the village level, everyday hazards determine the risk perception. In daily life, people are more concerned with immediate and tangible needs rather than longer-term ones. Sustainable solutions for the threats posed by mountain hazards are determined by institutions active in the village. These determine the risk perception, and cultural	

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
	government, community relations		influences determine factors pertaining to an acceptable level of risk.	
(Solana and Kilburn, 2003) Aims to gauge the awareness of landslide hazards.	The study assessed the effectiveness of non-structural methods in landslide risk mitigation in order to design effective programmes for hazard awareness. KW: landslide hazard, hazard awareness, hazard preparedness	Case studies of two communities vulnerable to landslides. Questionnaires were distributed and later collected through the local police network. Using the channel of a local body was effective in ensuring more questionnaires were returned. Qualitative observations.	Measuring perception of potential landslide risk was found to be the basis for implementing landslide awareness programmes. Frequent but low-intensity hazards can incur long-term expenses when they continually block roads and/or disrupt power and telephone lines. The community has not perceived the problem of rock falls (which were a concern for the scientists involved), and has no immediate concern for this particular hazard, which definitely exists. Clear differences in how risks were perceived by local residents and scientists from outside the community.	Considers that it is first necessary to gauge a population's understanding of landslides before implementing disaster risk reduction measures.
(Sullivan-Wiley and Gianotti, 2017) Study of risk perception in a multi-hazard context in Uganda.	Uganda. Risk perception according to different stakeholders at the community level. KW: risk perception, development organisation, disaster risk reduction, multiple hazards, Uganda	Risk perception survey conducted with personnel from RDO (non-governmental organisation working locally in disaster risk), farmers, householders and others. Based on a survey. Both quantitative and qualitative approaches	The major finding of the research is that factors shaping farmers' risk perception vary among different hazards within the same study population. Characteristics of both hazards and individuals shape risk perception. The study compared farmers in two locations that were dominated by different hazards. Education increases farmers' perception of the potential risks of farming.	Further research is suggested: prioritisation of risks by farmers when deciding what preventative measures to take; and an assessment in relation to the engagement of development organisations to work with the community.

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
		are applied when evaluating risk perception at the community level.		
(Zhang et al., 2010) Investigates the relationship between hazard proximity and risk perception in relation to house prices.	Two sites in Harris County, Texas. Risk perception mediates the influence of hazard proximity on property values. KW: hazard, risk perception, housing value, flood, hurricane, toxic chemicals	Quantitative measures were used for evaluating people's willingness to pay (or the price) as a function of the perceived risks. Data collection from owner-occupied, single-family houses in Harris County.	Because a house is the most significant investment made by most households, consequently, hazard proximity is a sensitive issue in relation to house purchase. The study finds a positive relationship with proximity to sources of hazard. In other words, people have a higher perception of losing a house and, therefore, are less willing to pay for apparently at-risk homes. This result consistently follows the hypothesis that perceptions of the risks from floods, hurricanes and toxic chemicals have a significantly negative relationship with distance to the property (i.e. a positive relationship with proximity) and the hazard.	The model assesses only the hazard proximity but cannot guarantee that risk perception is only a function of proximity. Several other factors influence and determine risk perception.
(Gurung, 1989) Aims to determine the perception and responses of local people in relation to mountain hazards and assess the implications for future land use policy.	Middle hills area of Nepal, north of the Kathmandu Valley in a community where agricultural-oriented livelihoods are typical. The context is a village with two ethnic groups. Road construction in the area after 1962 has increased the landslide risk and had an impact on	Ethnographic study. Two ethnic groups were the subject of the field-based perception study: Brahmin–Chhetri and Balamis (high vs low caste).	Farmers belonging to different socio-economic groups have different perceptions of landslide risk, and this has been one of the constraints with regard to taking action in terms of landslide mitigation measures. Landslides have caused new problems for framers in this subsistence community, including having an impact on food security. Land protection was a key issue. The government's protection measures are cost-intensive, and local people's opinions with regard to planning were ignored.	A gap was identified in that the public were not included in planning discussions about landslide mitigation measures. Suggests authorities have to consider public participation, despite already spending huge sums of money on mitigation measures and protection.

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
	people's livelihoods, but the impact on the two ethnic groups has been different. KW: landslides, mountain areas, ethnographic, perceptions		Therefore, community participation in planning is limited, especially in relation to government-initiated activities. Different social groups within the same community have a different perception of landslide risk even when living in the same physical setting. For example, the two ethnic groups that were studied have different social coping mechanisms despite living in the same village. In particular, one ethnic group has a more cohesive and cooperative social structure, which enabled them to cope better when facing challenges caused by natural hazards.	Suggests that a detailed risk perception study should be carried out prior to the implementation of structural and non-structural measures for mitigating landslide risk.
(Xu et al., 2016)	Three Gorges reservoir in China. Effect of individual and household characteristics on residents' perception of landslide risk. KW: risk perception, mass monitoring, household	Risk perception was assessed by measuring different variables: individual factors, household factors and community factors.	The survey was conducted among selected 'peasant' households, in which risk perception was, in general, relatively low.	The study mainly focused on rural areas and suggested studying an urban context for comparison.
(Landeros-Mugica et al., 2016)	Perception of landslide risk has been studied as a function of hazard exposure, experience and commitment to disaster risk reduction. This exploratory study considered the understanding of beliefs	Sampling methods applied in three neighbourhoods. Simple statistical tools used for measuring the relationships between the variables.	Concludes that gauging risk perception as a basic element for enhancing awareness and preparedness for disaster risk management was useful in cases in which 'people living in zones at risk but with no previous experience perceived higher risk for dwellers in other neighbourhoods than for another inhabitant of the municipality' (p. 1531). As well as physical mechanisms, anthropogenic factors that caused landslides were considered.	Study suggests a scenario-based approach for awareness-raising initiatives undertaken in communities.

Name/aim of the work	Context/case studies/keywords (KW)	Methods applied	Key issues in relation to findings	Research gaps identified/suggestions
	in determining perceptions of risk. KW: awareness, DRR, preparedness, risk perception			
(Bjønness, 1986)	Risk perception among the Sherpas in the Khumbu region of Nepal in the context of religious and socio-cultural factors, and how this is influenced by their experience of mountain hazards. KW: Khumbu, mountain hazard, experience	Interviews (individuals), literature review and investigation of a school class's perception of 'dangers in nature'. Key questions approach, and the use of ethnographic field methods to focus on the indigenous people's knowledge of actual hazards.	The location, perceived magnitude and frequency of hazards determine the landslide risk perception. Based on the responses from Lamas and members of the community, differences in perception of mountain hazards are significant. The degree of awareness among Sherpas varies with the individual, and there was a noticeable difference between those living close to hazards and those who reside further away. Mountain hazards have their roots in social and cultural factors that determine the ability to recognise and respond to premonitory signs that a threat is emerging.	

2.4 Factors influencing local understandings of landslide hazards and risks

Community understandings of landslide hazards and risks are influenced by several factors, including awareness of the hazard, previous experience, shared knowledge and access to educational materials (Solana and Kilburn, 2003; Paton et al., 2008; Calvello et al., 2016). Individual attributes including age, gender, education, caste and ethnicity (Bjønness, 1986; Gurung, 1989; Xu et al., 2016) are highly influential, as is direct personal experience of landslide hazard events, and hazard proximity (Zhang et al., 2010; Xu et al., 2016; Sullivan-Wiley and Gianotti, 2017). Critically, given this range of influences on understandings, perception of hazard and risk is not static but evolves over time, leading to different priorities that shape decision-making (Gurung, 1989). The perception could be in terms of categorising past hazard events based on the impact they have had on people's own lives (O'Neill, 2004). Alternatively, the perception could be based on the situations created by different types of hazard event, for example, infrequent but severe hazards, or everyday events (Haferkorn, 2018). Therefore, risk perception can be taken as a function of personal experience of hazard events, and such experience can be considered a driver of heightened risk perception.

It has been shown that a householder's economic conditions have a direct impact on perceived landslide hazards and risks. For instance, in an investigation of local farmers' perceptions in a landslide-prone village in the north of the Kathmandu Valley, Gurung (1989) found the perceived risk at the household level to be higher among those householders who had relatively better economic conditions. Thus, risk perception is also influenced by the economic circumstances of an individual household or community. In the case of a community, it depends on the community capacity for risk management, for example, if measures for protection can be taken (Alexander, 1991, 1992; Pilgrim, 1999). Moreover, risk is understood as the effect of repeated hazard events that could have a direct impact on people's livelihoods, for example, loss of farmland and farm production (Bjønness, 1986; Wagner, 2007; Klonner et al., 2018). The economic circumstances of the household, at least in part, influence its members' capacity to recover from the damage (Pidgeon et al., 2003; Haferkorn, 2018). As noted above, in Nepal, the growing rural road network in hill and mountain areas has led to roadside migration, with residents searching for economic opportunities. In some cases, this has led to the occupation of landslide-prone areas (Oven, 2009; Lennartz, 2013). In such locations, research has shown that householders evaluate the risk of comparatively infrequent landslides against the economic and livelihood opportunities that the location presents (Oven, 2009), resulting in changes in exposure over time. Such changing exposure has been visible in several locations in Nepal's middle hills area when new highways and feeder roads were constructed, especially from the 1960s onwards, with the associated risk of triggering landslides (Gurung, 1989; Lennartz, 2013). It can also be seen in relation to local road construction in recent decades, which is often associated with minimal engineering input and less risk of triggering landslides (Sudmeier-Rieux et al., 2013; Jaboyedoff et al., 2016; Vuillez et al., 2018). Moreover, landslide hazards and risks in Nepal increase when tipped material and undercut slopes remain unstable after construction or widening (Lennartz, 2013; Sudmeier-Rieux et al., 2013; Devkota et al., 2014; Sudmeier-Rieux et al., 2019). The risk of landslides, and how this is understood, is very much in the shadow of the anticipated potential economic and social benefits after local road construction.

Social factors are critical in decision-making with regard to landslide risk (Misanya and Øyhus, 2015; Bisri and Beniya, 2016; Shalih et al., 2020). Good social networks or interactions can enhance coping capacities when facing hazards (Bormudoi and Nagai, 2017), and the strength of a household's social network, that is, the safety net of their family or community, is vitally important in this respect (Lee, 2016). Different social groups may have different understandings of hazards and risks even when living in the same physical environment. The understandings may vary because of the resources available, leading to differing coping capacities despite the same physical setting (UNDP, 2009; Lee, 2016; Antronico et al., 2019). Gurung (1989) compared the landslide risk perception of two ethnic groups, the Balamis and the Brahmin–Chhetri, who live north of Kathmandu. This study found that the two ethnic groups typically have different social coping practices: Balamis tended to adopt a more cohesive approach based on a cooperative model as compared with the Brahmins, and this enabled the Balamis to face hazard and disaster events collectively (Gurung, 1989). Moreover, Bjønness (1986) assessed the perceptions of mountain hazards and environmental threats among inhabitants of the Khumbu area of Nepal. The research considered how the community perceives, interprets and reacts to warning signs based on previous experience, and found that perceptions of mountain hazards were strongly rooted in social and cultural understandings of the environment. Thus, risk perception is also influenced by the socio-cultural situation.

In addition, cultural values and beliefs are highly influential in determining what people consider to be an acceptable level of risk (Pilgrim, 1999; Bankoff, 2003; Krüger et al., 2015). For instance, personal attachment to the location due to religious beliefs and family ties might influence motivation or decision-making in relation to risk reduction (Mercer et al., 2008; Oven, 2009; Wanasolo, 2012; Tamang, 2020; Oven et al., 2021). The example from Nepal's Khumbu region (Bjønness, 1986) finds people continue to live in the area even though hazardous events occur frequently. The religious-minded Sherpa community in the Khumbu region generally have a higher perceived level of disaster risk and are more concerned than other ethnic groups living in the area about the potential impact of natural hazards (Bjønness, 1986). Despite this, they continue to live there, i.e. livelihood availability (Wachinger et al., 2013b; Hicks et al., 2014; Roder et al., 2016). Risk perception reflects personal, cultural and social biases linked to the site's symbolic and cultural values and, therefore, the inhabitants' intuitive reactions to the place and environment (Dahal and

Hagelman, 2011; Oven et al., 2021). In such a context, perceived landslide hazards and risks vary along community cultural transects.

Demographic characteristics such as gender, age and education level are major factors influencing perceived level of risk (Calvello et al., 2016; Xu et al., 2016; Hernández-Moreno and Alcántara-Ayala, 2017; Covey et al., 2019). The role of gender in perceived risk was documented vividly by research in Bucharest (Armaş, 2008), where women were found to be more concerned than men about earthquake risk. Similarly, older citizens in a community in China were more concerned about natural hazards and had a higher level of risk awareness than young people (Lai and Tao, 2003). At the same time, in the Three Georges river basin in China, people with a higher level of formal education were also reported to be more aware of landslide risk (Xu et al., 2016). Therefore, demographic characteristics may influence adaptive behaviour, motivations and actions, for example, mitigation behaviours undertaken within the household and community (Haynes et al., 2007; Covey et al., 2019).

Prior experience of disaster events can also influence the perceived level of risk (Xu et al., 2016). Local knowledge and experience generally reflect the frequency and consequences of previous events (Bjønness, 1986; Pilgrim, 1999; Ho et al., 2008). In general, if the community has past experience of a hazard event, they are more likely to have a heightened level of risk perception (Gurung, 1989; Siegrist and Gutscher, 2006; Manandhar et al., 2015) For example, people who have past experience of floods are more worried about them reoccurring because of the resulting impact on their lives and livelihoods.

In relation to prior experience, the event's frequency and magnitude can influence risk perception (Sattler et al., 2000; Kellens et al., 2013; Wachinger et al., 2013b; Calvello et al., 2016). As such, risk can be perceived according to the sense of potential loss caused by such events – how often, or how big – and this can vary independently of event magnitude (e.g. a large landslide does not necessarily result in more fatalities than a small landslide). In addition, the collective impact of smaller individual events, for example, successive landslide lake outburst floods, a phenomenon that is very common in the UBK, can influence risk perception (Cook et al., 2018). Occasionally, a single such event of much greater magnitude occurs, often because of the catastrophic failure of a landslide dam, and the damage caused by this is added to the landslide damage caused by the annual monsoon flood, again affecting risk perception. The most recent event of this type occurred in 2016, when the Bhote Koshi river was hit by a GLOF in July of that year (Xu, 1988; Khanal et al., 2015; Jianqiang et al., 2016; Guo et al., 2017; Kincey et al., 2020; Tian et al., 2020). Hence, past experience of hazard events of various magnitudes and their frequency may influence local people's understandings of risk, for example, those living along the Arniko Highway in the Bhote Koshi river basin. The Jure landslide in 2014, the 2015 GE and the GLOF in 2016 have caused real concern among the valley population. Along with these much rarer events of greater magnitude, a continuous stream of small-scale events continues to be interwoven with everyday lives in the valley, and the two together have compounded to influence the risk perception of those experiencing the effects of these hazards (Siegrist and Gutscher, 2006; Paton et al., 2008; Crozier and Glade, 2012).

In addition, communities or families do not necessarily categorise all locations as equally at risk, reflecting both local and indigenous knowledge (Johnson et al., 1982; O'Neill, 2004). O'Neill (2004) considers the spatiality of risk in the context of community safety, and highlights the tendency to either over or underestimate the risk based on understandings of either potential direct or indirect impacts according to past experience. This kind of anticipation of the degree to which a location is exposed to a hazard could be weighed against the benefits of living in a given location (Starr, 1969). Moreover, the perceived level of risk can be strongly related to attachment to a particular place, whereby long-term ties to land, livelihood networks or places of cultural and religious significance may be viewed as less risky given their cultural value (Sou, 2014; Sherry and Curtis, 2017; Aksha and Emrich, 2020; Shalih et al., 2020; Oven et al., 2021). In may also be the case that the poorest and most vulnerable householders may value such a sense of attachment to place, despite the dangers (Titz et al., 2018). For instance, even though people are aware of the risk of a GLOF in relation to the Tsho Rolpa glacial lake in Nepal's mountainous region, communities were found not to be afraid of the potential risks downstream (Dahal and Hagelman, 2011). Although many placed a high level of trust in government-installed early warning systems, at the same time, the study by Dahal and Hagelman (2011) observed repeated false warnings, which, essentially, were found potential to harm public trust in the risk information they were given. Additionally, the economic benefits of tourism in downstream communities mean that many were unwilling to relocate, even when there were warnings in place (Dahal and Hagelman, 2011). Such studies highlight how communities' priorities differ according to local contexts, their attachment to place, religious and cultural significance, livelihoods, etc., rather than any rule-based scientific view of risk (Dillon and Tinsley, 2008; Sherry and Curtis, 2017; Sherry et al., 2018).

People's decision-making in relation to whether they should stay or move is complex, and may involve different opinions and an individual's willingness (Oven et al., 2021). The willingness to take action will be determined, at least to some extent, by the householder's assessment of risk levels (Damm et al., 2013). Hence, the decision with regard to taking any protection measures appears to be based on householders' evaluation of potential risk, which is weighed against their capacity to adapt (Landeros-Mugica et al., 2016). Moreover, families with a history of losing their homes during previous events have been shown to have a greater willingness to move from their present location (Damm et al., 2013), whereas householders with no experience of previous hazard events and their outcomes may consider themselves safe and so prefer to stay put (Landeros-Mugica et al., 2016).

Moreover, after the 2015 GE, the experience in Nepal shows that the need for livelihood opportunities has been the highest priority for householders when identifying new places to live, and these sit within a wider suite of social challenges and considerations (Oven et al., 2021; Shrestha and Bhatta, 2021). Therefore, householder or community prioritisation depends on the perceived benefits of moving or staying put.

Local stakeholders, such as community organisations and active village institutions, have a vital role in influencing how risk is understood and considered within local decision-making processes. Pilgrim (1999) assessed the role of local institutions in community perception of landslide risk in the Himachal Pradesh region of India, and found that they acted as key agents in changing risk perception, raising awareness and promoting advocacy at the local level (Pidgeon, 1998; Pilgrim, 1999; Paton et al., 2008). These local institutions, which include community-based organisations (CBOs), NGOs, civil society groups and local community groups (e.g. *tole* (neighbourhood)) groups, mothers' groups and community forest user groups, have been widely discussed in research (Oven and Rigg, 2015; Bustillos Ardaya et al., 2017; Sherry and Curtis, 2017; Titz et al., 2018). They are an important part of the community in that they intervene to inform and enhance local understandings of hazards and risks. Ultimately, this leads to shaping public opinion in relation to LRM. Such interventions are widely recognised as an important tool for building awareness of local problems, providing information and educating local people living in risky areas (Crozier and Glade, 2012; Bustillos Ardaya et al., 2017; Sullivan-Wiley and Gianotti, 2017; Titz et al., 2018; Vuillez et al., 2018). Similarly, in Nepal, our own research as part of the study exploring the impact of earthquake-triggered landslides on two communities in Sindhupalchok District has highlighted the role played by influential religious institutions and local leaders in shaping decision-making in relation to whether to relocate, in response to the GoN's assessment of landslide risks (Oven et al., 2021).

Communities commonly hold relatively detailed knowledge about their local landscape, hazard occurrence in the past, rainfall and other environmental changes experienced (Wagner, 2007; Reichel and Frömming, 2014). Knowledge gaps can be observed too, particularly in relation to large, high-magnitude hazards, which may not have been experienced in living memory. As a result, relying on local knowledge alone can potentially underestimate the degree of hazard and risk faced, highlighting the potential vital role of outside 'expert' knowledge in supplementing local knowledge for effective DRR (Vari, 2002; Barberi et al., 2008; Tappenden, 2014; Davies et al., 2015; Hernández-Moreno and Alcántara-Ayala, 2017). For instance, householders and the community may welcome new information on the causes of landslides and how mitigation options will work to reduce landslide risk effectively, if these have not been previously tried or experienced (Maes et al., 2017; McAdoo et al., 2018). Invariably, multiple factors shape local understandings of hazards and risks, and there is a role for both internal and external stakeholders in providing information, including those with a formal role in the governance of local landslide hazard and its mitigation.

2.5 Landslide hazard and risk communication

Risk communication has gained significant importance as the need for raising awareness of disaster risk has become paramount, in part related to the priorities of the UN's Sustainable Development Goals (SDGs) and associated initiatives (O'Neill, 2004; Bradley et al., 2014; Hernández-Moreno and Alcántara-Ayala, 2017; Abunyewah et al., 2018) such as the Sendai Framework for DRR (UNISDR, 2015). The primary goal of risk communication in DRR is to inform, raise awareness and motivate, thereby enhancing a community's preparedness (Bradley et al., 2014; Hernández-Moreno and Alcántara-Ayala, 2017; Abunyewah et al., 2018). Nepal is a mountainous country, and Nepali communities are exposed to various types of landslide and other related geohazards (Robinson et al., 2017, 2018), and the risks associated with them. Hence, there is a serious need to establish an effective risk communication system to reduce the losses attributed to landslide hazards. At present, there is no significant effort focused on landslide risk communication that actually reaches those most at risk in Nepal.

Risk communication refers to using relevant ideas (often from science) to address people's needs and problems and is commonly described as a two-way interaction or exchange of information between stakeholders (Hicks et al., 2014; Calvello et al., 2016; Salvati et al., 2016; Shaw et al., 2017; Abunyewah et al., 2018; Haferkorn, 2018). In this sense, a dialogue promotes and strengthens understandings of complex hazards through the sharing of knowledge between experts, both lay and scientific (Hernández-Moreno and Alcántara-Ayala, 2017; Stewart and Lewis, 2017; Abunyewah et al., 2018). Traditional risk communication models have been criticised for their one-way information flow, which is commonly downwards from the institutions at the top to communities at the bottom (Mitchell et al., 2008). Such approaches often undervalue and ignore public knowledge (Bradley et al., 2014). Recent developments in risk communication are more concerned with promoting a partnership between people who are 'at risk', scientists and policy-makers (Hicks et al., 2017). Hicks et al. (2017) provided an example of this, which was monitoring a local volcano in partnership with scientists and at-risk communities. Subsequently, this promoted the building of partnerships and trust under the Strengthening Resilience in Volcanic Areas (STREVA) project. Rowan (1991) illustrated that a proper risk communication tool could benefit communities by establishing trust among stakeholders with the intention of raising awareness, building consensus and motivating actions. For example, in a study of hazard communication in the 14 most severely affected districts in Nepal after the 2015 GE, Saha et al. (2021) found nearly two-thirds of regular radio listeners knew about techniques to build earthquake-resistant foundations for houses that had been suggested by the government, and nearly half (45%) reported using such techniques. Therefore, if communication is to have a high success rate, it depends on a number of factors, including the messages and the means of communication being tailored to the target audience (Le Coz et al., 2016).

A range of tools and methods taking into account varying levels of literacy and numeracy are often used to explain complex information to communities in an accessible manner. There are several examples of landslide risk communication tools that can be drawn from the literature. The first simple method is the visualisation of an inventory of landslide hazard events disseminated through openly accessible portals or platforms, or community noticeboards, for example, the DesInventar database (2021) (https://www.desinventar.net/), Nepal's BIPAD (Building Information Platform Against Disaster) portal (2021) managed by the National Disaster Risk Reduction and Management Authority/GoN (https://bipadportal.gov.np/) and the EM-DAT (2021) database (https://www.emdat.be/). These approaches are relatively simple as a means of risk communication, but have been criticised for not capturing all events, lacking local context and focusing on extremes. In addition, rarely do they concentrate on the everyday hazards, which are often small in size (Aksha et al., 2018; Jimee et al., 2019; Panwar and Sen, 2020). In cases in which information is more advanced, numerical or requires more detailed explanation, issues associated with its effective communication can inhibit its use. For example, outputs from hazard and risk modelling tools (e.g. Robinson et al., 2017) commonly produce a large volume of data, often in map form, which can often be abstract or very different from data normally used by stakeholders. Although this information can be a particularly reliable source of information for academic and educated technical audiences, making it accessible and valuable at the community level can be a very different challenge (e.g. Rosser et al., 2021).

An example from the Kathmandu Valley Earthquake Risk Management Project (KVERMP) provides a vivid illustration. This project attempted to explain the potential loss scenarios for a hypothetical IX intensity earthquake in the Kathmandu Valley (Dixit et al., 1999, 2013). The project included a simplified earthquake scenario supported by comprehensive calculative analysis and an associated disaster risk management action plan at local ward level. The results showed the potential impact in terms of the loss of human life, property and infrastructure (Dixit et al., 2000). The loss scenarios were widely disseminated among various stakeholders, including agencies responsible for both response and preparedness in the Kathmandu Valley. A critical lesson learned from KVERMP was that raising awareness was crucial. The project found a low-tech approach was best for transferring risk knowledge and project implementation, and it emphasised community activities using school earthquake safety initiatives as a good starting point for communicating risk concepts effectively (ADPC, 2000; Dixit et al., 2000). The results from KVERMP illustrated three important facets of a successful approach to risk communication: (a) the importance of targeting different groups with tailored messaging, for example, government officials, members of international agencies resident in Kathmandu, the media and residents; the scenarios generated were developed based on scientific results but were presented in a simplified manner, which was intended to enhance community awareness of earthquake risks, and give communities confidence in their own ability to reduce these risks; (b) the use of a low-tech approach, which adopts a simple but technical basis that was understandable for the layperson; and (c) the importance of emphasising community work as a means of trying to embed earthquake-safe practices into everyday working practices (Dixit et al., 1999, 2013; Dixit et al., 2000). KVERMP further suggested engagement of local specialists as one of the best methods of addressing local problems (Dixit et al., 2000; Rodgers et al., 2020). Similar methods have been used to develop an earthquake scenario for stakeholders in China using a participatory approach (Rodgers et al., 2020), and an earthquake hazard scenario for Nepal (Chamlagain, 2009).

A second form of innovative risk communication in Nepal is the shake table model (Upadhyay, 2004; Dixit et al., 2013), which demonstrates earthquake-safe construction of buildings. Two buildings are constructed to a reduced scale, generally 1:10, side by side on a platform that can be shaken mechanically. The two model buildings are made out of commonly used construction materials, with the same broad architectural design as employed locally. One of the models is made with full building code compliance and another is built as per the prevalent local building construction practices. Under shaking, the latter rapidly becomes damaged, and ultimately collapses as the intensity of shaking is increased. The shake table is a communication tool that is demonstrated in public, showing and directly explaining the different performance of each building (Figure 2-2). The visual impact is significant, demonstrating practical and accessible mitigation measures through relatively small-scale interventions with little added cost, making an enormous difference. The shake table demonstration has evolved to motivate people by presenting the underlying complex scientific facts in an accessible manner (Shrestha et al., 2012; Dixit, 2014; Dixit et al., 2018). More comprehensive lessons from the shake table demonstrations have been learned through on-site discussions with the community, which can lead to further problem-solving. This approach has been developed directly from the broader literature concerning the use of participatory models, demonstrations and theatre in DRR (Gaillard and Maceda, 2009; Rambaldi, 2010; Gaillard et al., 2013). Such interactions help to build a trust-based relationship between stakeholders, which is vital in risk communication and making use of risk information (Haynes et al., 2008; Stone et al., 2014).

Examples of good practice in hazard and risk communication from Nepal include the national Earthquake Safety Day (ESD), which aims to raise awareness of earthquake risk, preparedness and DRR (MoHA, 2019; Dixit et al., 2013). ESD has been celebrated in Nepal since 1999 with a range of partners working on DRR in Nepal, including government organisations, municipalities, NGOs (local and international) and local communities. This initiative, which was envisioned and implemented by the national NGO NSET, and later continued by the GoN, is now celebrated annually in commemoration of the Great Bihar–Nepal earthquake of 1934. ESD's approach focuses on creating awareness in relation to earthquake risk reduction and sharing information and knowledge among a wide range of stakeholders (Jimee et al., 2012). The ESD celebration itself consists of multiple interactive activities, including discussions about earthquakes and risk reduction in the media, technical sessions on different earthquake risk themes, simulations of different activities (e.g. the shake table), demonstrations of best practices for safe construction of houses, safety drills, exhibitions, safety rallies, walkathons and street theatre (Dixit et al., 2000; Dixit, 2003). Thus, ESD provides a highly effective interactive platform for raising awareness and advocacy tools for increasing knowledge with regard to how to build safer earthquake-resistant houses, and also motivates the people to become decision-makers (ADPC, 2000; Chamlagain, 2009; Jimee et al., 2012; Kelman, 2015; Shriner, 2018).

Figure 2-2. Public demonstration of a shake table. (Source: NSET – Nepal, www.nset.org.np).

There are other practical means of risk communication in Nepal, for example, in the post-2015 GE reconstruction context, Saha et al. (2021) assessed the effect of BBC Media Action radio programmes *Milijuli Nepali* (Together Nepali) and *Katha Maala* (Garland of Stories), which were both focused on reconstruction issues. The study looked at affected communities and assessed the programmes' influence on people's knowledge of issues and concerns in relation to reconstruction by using metaphors to communicate messages about different features such as strong foundations, strengthening walls with lintel bands, lighter roofs, etc. The approach was found to be highly effective in ensuring engagement by listeners and in visualising what were quite technical concepts. However, selecting the best approaches for addressing and meeting community needs for information has always been challenging (Hernández-Moreno and Alcántara-Ayala, 2017). The lessons learned in the various examples discussed above indicate that live demonstrations are a particularly attractive option in the context of landslides in Nepal.

2.6 Elements of risk communication

Based on previous research conducted at the community level, several factors influence the effectiveness of risk communication, and it is important to take into account a number of elements when considering the best approach for communicating information on natural hazards (Haynes et al., 2007). These include the incorporation of information on the source of hazards, a means of exchanging clear and appropriate messages between stakeholders and a mechanism for collecting feedback (Lindell and Perry, 2003, 2012). In communicating messages, building trust is vitally important, particularly in relation to the reliability of the source of the information that is being shared with the audience (O'Neill, 2004; Haynes et al., 2007; Dahal and Hagelman, 2011). Moreover, trust develops confidence in local communities and authorities and, therefore, its existence is more likely to promote action (Lindell and Perry, 2003; Abunyewah et al., 2018; Safford and Brown, 2019). To conceptualise risk communication, Mitchell et al. (2008) consider it can be divided into the following four categories: (a) the traditional approach to risk communication (Lee, 1986), which includes information sources, messages, channels and receivers; (b) the behavioural tradition (Slovic, 1986), which is based on understandings of perceptions and attitudes, and cognitive mapping; (c) social, political and economic factors that influence vulnerability (Wisner et al., 2004); and (d) the cultural tradition, which advocates deliberation of messages between the public and other stakeholders who are interested in risk information (Chilvers, 2005). More recently, emphasis has been placed on more participatory approaches that advocate early deliberation (Chilvers, 2005). The participatory approach to risk communication offers opportunities for exchanging knowledge and integrating this into local DRR activities (Mercer et al., 2009; Lane et al., 2011; Gaillard and Mercer, 2012; Gaillard et al., 2013, 2016). In this thesis, I aim to expand such work and develop a more participatory approach involving active community engagement that is based directly on the knowledge gaps and needs identified in my household survey and PMEs.

A communication channel is the medium through which risk messages are conveyed (Lindell and Perry, 2003; Salvati et al., 2016; Haferkorn, 2018; Sharma et al., 2021), and examples are as follows: simple hazard and risk maps provided to communities, local authorities and decision-makers (Rosser et al., 2021); narrative-based loss or damage scenarios (Dixit et al., 1999; Dixit, 2003; Adhikari et al., 2013; Robinson et al., 2017); audiovisual materials, for example, films, for improving risk knowledge and preparedness (Sanquini et al., 2016a; Hicks et al., 2017); and scaled demonstrations such as the shake table (Dixit et al., 2013; Dixit, 2014). Content should be simple and clear, able to be understood locally and actionable (Rowan, 1991; Sanquini et al., 2016a; Safford and Brown, 2019). Indeed, Bradley et al. (2014), in the context of an intervention warning about the likely effects of impending cyclones, recommend that messages are translated into local languages and disseminated orally, emphasising that important and effective action can be undertaken to reduce disaster risk. Risk information and messages need to be credible and consistent to meet audience expectations, and they must answer questions and concerns (Bradley et al., 2014).

Dialogue between the public and experts is central to meaningful risk communication (Stewart and Lewis, 2017). Dialogue offers opportunities for exchanging ideas, collaboration and working together with communities (Dixit et al., 2013, 2018; Dixit, 2014; Hicks et al., 2014; Ickert and Stewart, 2016). In recent years, dialogue with communities has been increasingly recognised as a means of helping to promote local engagement and participation, of aiding the discussion and exchange of ideas and of fostering a notion of ownership of the process and output in relation to any hazard mitigation proposal (Paton et al., 2008; Hernández-Moreno and Alcántara-Ayala, 2017). Meaningful communication relies on the shift in mindset from imparting information on 'matters of fact' to imparting information on the 'matter of concern' (Latour, 2004; Stewart and Lewis, 2017). For example, the shake table demonstration is considered to be an effective tool for promoting dialogue and engaging people in a discussion about the role of effective mitigation initiatives in reducing risk (Dixit et al., 2013; Dixit, 2014). These live demonstrations are focused on developing public trust in intervention measures by providing a forum for dialogue and responding to questions interactively, transparently and in public (Lindell and Perry, 2003; Gaillard et al., 2013; Mani et al., 2016).

O'Neill (2004) emphasises that effective risk communication strategies need to be in place, particularly where hazards and risks could harm communities. These might be hazards that are unpredictable or unprecedented (Hearn, 2013; Chaudhary et al., 2019), as is often the case with landslides. O'Neill (2004) further suggests that risk communication needs to be designed to build on the current level of risk perception held by communities and their willingness to engage in risk reduction activities. Inevitably, the challenges are associated with acceptance, motivation and the socio-economic ability to invest in risk reduction should take into consideration.

2.7 Integrating local knowledge in relation to landslide risk reduction with scientific knowledge

Gaillard and Mercer (2013) propose a roadmap to be used in a participatory approach for integrating different forms of knowledge and actions in DRR (Figure 2-3). In this model, various actors play a role and make their contributions towards achieving the goal of DRR in communities. The model suggests combining scientific knowledge and local knowledge for risk assessment. Essentially, both of these will contribute towards DRR activities through dialogue and then actions. The 'risk assessment' element of the model plays a secondary role to knowledge integration, which aims to recognise and value the local knowledge held within communities (Mercer et al., 2010) and the practices they use. If local knowledge is then combined with scientific techniques (and knowledge), both can then be used for improving DRR initiatives at the local level (Reichel and Frömming, 2014). Moreover, knowledge integration as proposed by this model promotes active participation of communities through a number of interactions, for example, participatory mapping and live demonstrations (Cadag and Gaillard, 2012). In doing so, the model includes both top-down and bottom-up approaches, as shown in Figure 2-3, in which several stakeholders are involved or participate in the different stages of risk assessment, dialogue and actions within the process according to their roles (Oven and Rigg, 2015). However, this process might be challenging to operationalise on the ground (Cadag and Gaillard, 2012, p. 101), because of the unique nature of local knowledge in communities, which is distinct in form and nature from 'the international knowledge system generated by universities, research institutions and private firms' (Warren, 1991, p. 1). Local knowledge in particular and the model in general are perhaps most appropriate for understanding day-to-day hazards, and there are some concerns in relation to how such models fit high-magnitude hazard events, for example, the 2015 GE, and more everyday risks concurrently.

Historically, risk communication has been predicated on the broad structure of the knowledge deficit model (Simis et al., 2016). Empirical research on the knowledge deficit model has shown that communicating risk is complex, and often assumes the lack of information or knowledge among communities (Simis et al., 2016). The generally proposed remedy is one-way communication where the information flows from experts to the public (Suldovosky, 2017). Managing the relationships that emerge over the time between 'experts' and 'non-experts' is vital in successful communication around hazards and risk. In the traditional sense, the deficit model also assumes a lack of information, where experts can provide more reliable information to the audience, and recommend relevant information of public concern or identify issues that need to be disseminated (Abunyewal et al. 2020). The model assumes that adequate information can lead to behavioural changes in proactive disaster risk management (Wynne, 1993; Chilvers et al., 2005). In the recent past, the deficit-model has been critiqued for its centring around the operationalisation of the process itself, and the potential limits on the effectiveness of risk communication in exchanging ideas (Esteban et al., 2016). A more participatory approach to knowledge exchange is recommended for achieving more successful risk communication by promoting dialogue or two-way communication (Stewart and Lewis, 2017), which the deficit model lacks. Hence, the approach to risk communication taken by the deficit model (i.e., effective implementation of information dissemination (Gregory and Lock, 2008)) shifts from a traditional to a new 'contextual model' with stakeholder engagement leading to knowledge production (Abunyewah et al., 2020).

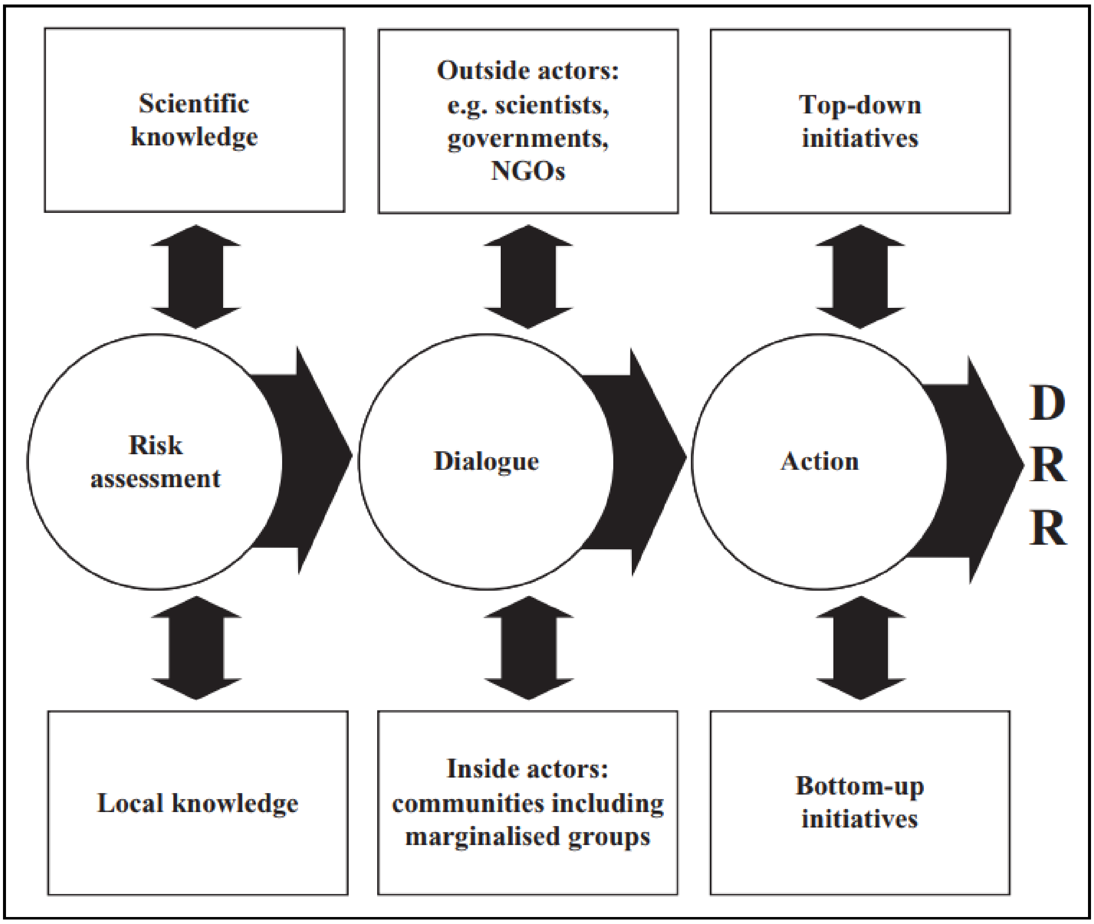


Figure 2-3. Conceptual model for knowledge integration between different stakeholders involved in disaster risk reduction at the local level. (Source: Gaillard and Mercer, 2012, p. 95).

NGOs: non-governmental organisations; DRR: disaster risk reduction.

This approach can overcome the criticisms of the information-deficit-model by attempting to combine expert knowledge and community knowledge within a participatory approach (Suldovsky, 2017; Stylinski et al., 2018; Stewart and Lewis 2017). As a result the current practice involves a move towards a more 'contextual-model' that aims to achieve effective hazard and risk communication by being grounded in social science research methods that encourage active community participation and direct engagement with the available scientific basis on the issues of concern (Simis et al., 2016). Stylinski et al. (2018) go on to recommend a comprehensive strategy to promote community engagement where scientists create their own outreach strategies to reach the public and provides opportunities to offer a unique way of information access to audiences (Stylinski et al., 2018).

Since the 1970s, the importance of integrating local knowledge and practices for managing natural hazards with more scientific knowledge has been recognised. Academics and practitioners have highlighted the value of local knowledge within communities for DRR (Mercer et al., 2010), emphasising its potential for risk mitigation, assessing local risks and developing action plans (Dekens, 2007; Shaw et al., 2008). Moreover, the experience of KVERMP (ADPC, 2000; Dixit et al., 2000), mentioned earlier, involves a number of activities at the community level that reflect a similar set of underlying principles. PMEs have been one of the most powerful means of accessing and bringing to the fore local knowledge about hazards and risks and integrating this with scientific knowledge. When this process is translated into maps, it enables local communities to create an active dialogue with both local and external stakeholders (Figure 2-3). As Cadag and Gaillard (2012) confirmed, collaboration between local and scientific communities using participatory exercises based on a large-scale map holds the potential for knowledge integration in relation to local disaster preparedness planning at the village level (with the example of Sapang Kawayan, p. 105) and for improving risk assessments at the local level.

2.8 Summary and conclusion

The majority of the studies and research literature reviewed here conclude that effective risk communication has the potential to enhance knowledge in order to improve risk reduction efforts. The empirical evidence suggests that the effectiveness of such initiatives might not be linear, and that, in fact, methods, tools and context fluctuate back and forth in line with communities' characteristics, notably in relation to community understandings in a given context and the socio-economic and cultural context (Alexander, 1992; Chan et al., 2007; Bradley et al., 2014). Scientific research on risk communication in relation to natural hazards in Nepal mainly focuses on hydro-meteorological hazards (Bradley et al., 2014), floods (Liu et al., 2018), and earthquakes (Dixit et al., 1999, 2013; Dixit, 2003, 2014). There are a very limited number of studies on landslide hazard and risk communication focusing on community engagement in Nepal, or beyond (Alcántara-Ayala et al., 2004; O'Neill, 2004; Sanquini et al., 2016a; Sharma et al., 2021). This could be due to the complex nature of landslide process and the difficulties involved in implementing such a study effectively within communities (Chan et al., 2007), as well as landslides being a relatively overlooked hazard.

In recent decades, the extent of landslide hazards and risks has increased in Nepal because of changing geophysical and anthropogenic conditions. High-magnitude events such as the 2014 Jure landslide and 2015 GE revealed several aspects of landslide risk that communities face daily, but also gaps in knowledge when facing more unusual or extreme circumstances. Understanding community perceptions of everyday landslide hazards and risks at the individual, household and community level has been a key precondition for developing and implementing effective DRR. Better ways of managing landslides and reducing the risks they pose can be communicated to the people involved through participatory dialogue that aims to inform, raise awareness and enhance community preparedness by putting local knowledge at the centre of the process. This review forms the basis of the ideas that I explore in this thesis with regard to improving community understandings of landslide risk.

Chapter 3

Methodology

3.1 Introduction

This chapter lays out the methodological process adopted for the research by providing an overview and explaining how the chapters link together. Here, I present a summary of the methods, and the context in which I have conducted my research to help me achieve the aim of the study. I intend to map out the overall structure and approach to enable the reader to follow the thread running through my research and to understand the design I developed from the outset. Further details on the specific methods for each part of the research are fully explained in the chapters that follow.

3.2 Study area

3.2.1 UBK

The chosen study area lies in the UBK, within the Bhote Koshi *Gaunpalika* (rural municipality) (BKGP) in the Sindhupalchok District of Central Nepal (Figure 3-1). The UBK is an important transboundary river basin straddling Nepal and Tibet, and lies in an area that is very prone to landslides and debris flows because of its geophysical and climatic characteristics (van der Geest and Schindler, 2016; Liu et al., 2020). As a result, debris flows, with poorly sorted and saturated sediments (Adhikari and Koshimizu, 2005), as well as GLOFs, are commonplace (Liu et al., 2020). The valley receives *c.*71%–92% of annual rainfall during the monsoon (Adhikari and Koshimizu, 2005) between June and September, amounting to 2,500–3,000 mm of precipitation. Landslides are highly seasonal events in Nepal, especially during the monsoon, and they are triggered by intense and often sustained rainfall (Figure 3-2). In the UBK, it is very common to observe river and channel bank erosion, leading to the retreat of steep valley wall landslides that causes further erosion and undercutting at the base of the valley slopes (Cook et al., 2018), see Figure 3-3. Topographically, the valley is narrow and steep, characteristic of a chronically unstable, highly rugged mountain area with deep gorges (Adhikari and Koshimizu, 2005).

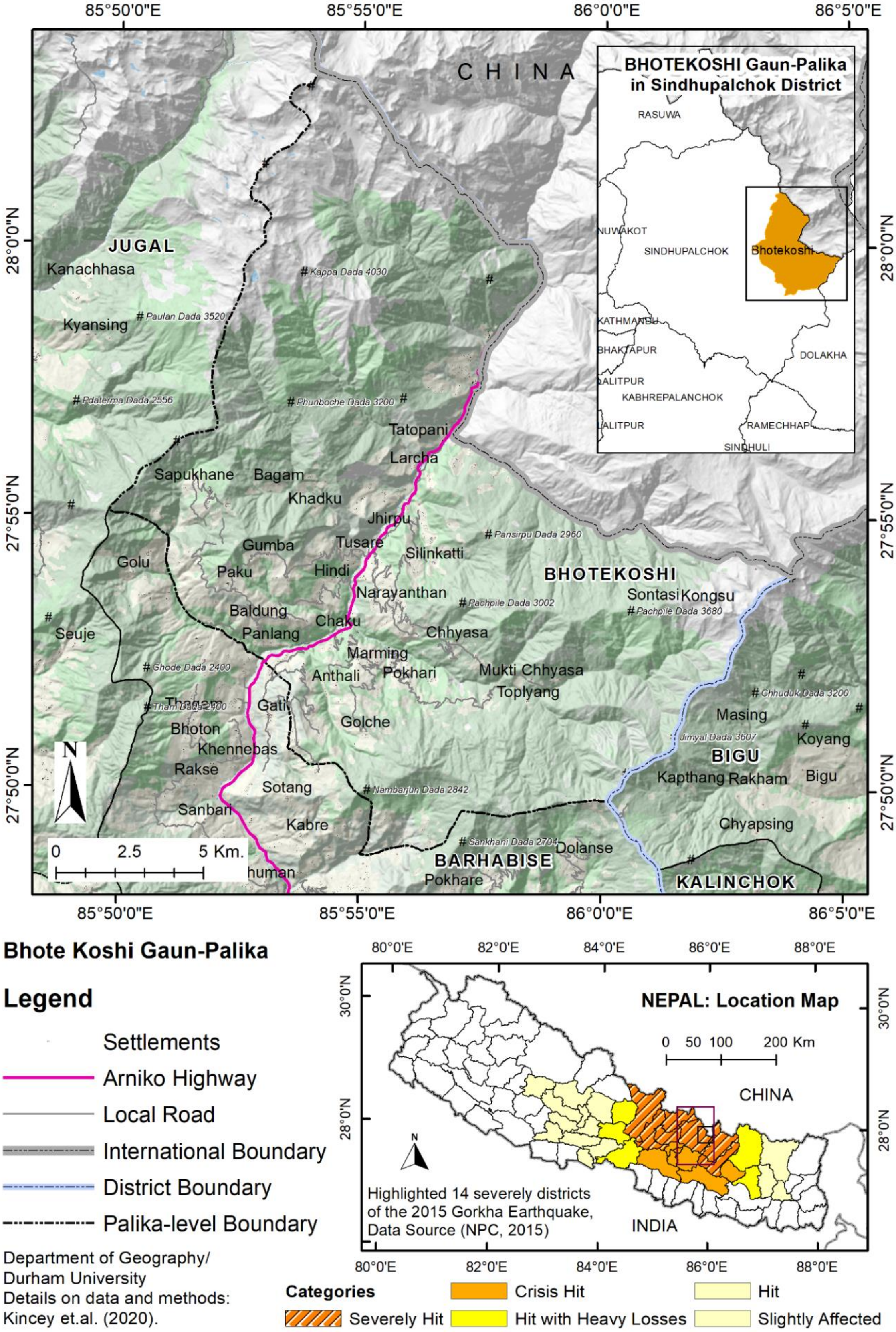


Figure 3-1. Location of the Bhote Koshi *Gaunpalika* in Sindhupalchok District, Central Nepal. (Source: Department of Geography, Durham University/NPC, 2015).

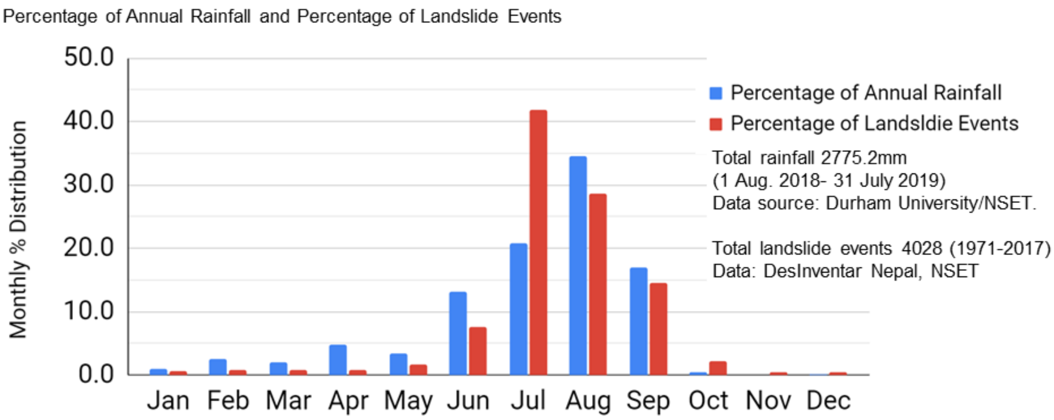


Figure 3-2. Seasonality: Monthly rainfall records in the UBK and monthly landslide events in Nepal.

Figure 3-3. Photographs showing landslides along the Bhote Koshi river (above), and landslides along the Chhyadi Khola and Chaku Khola (below).

Additionally, the area is also a complex tectonic sequence of steeply dipping phyllite, schist, gneiss, limestone and quartzite formations overlaid with highly weathered colluvial and alluvial deposits, which is cut through by the inactive Main Central Thrust of the Himalaya, see Figure 3-4 from DMG (2005). The valley is linked to the capital city of Kathmandu by the Arniko Highway, which connects Kathmandu to the Chinese border in the north.

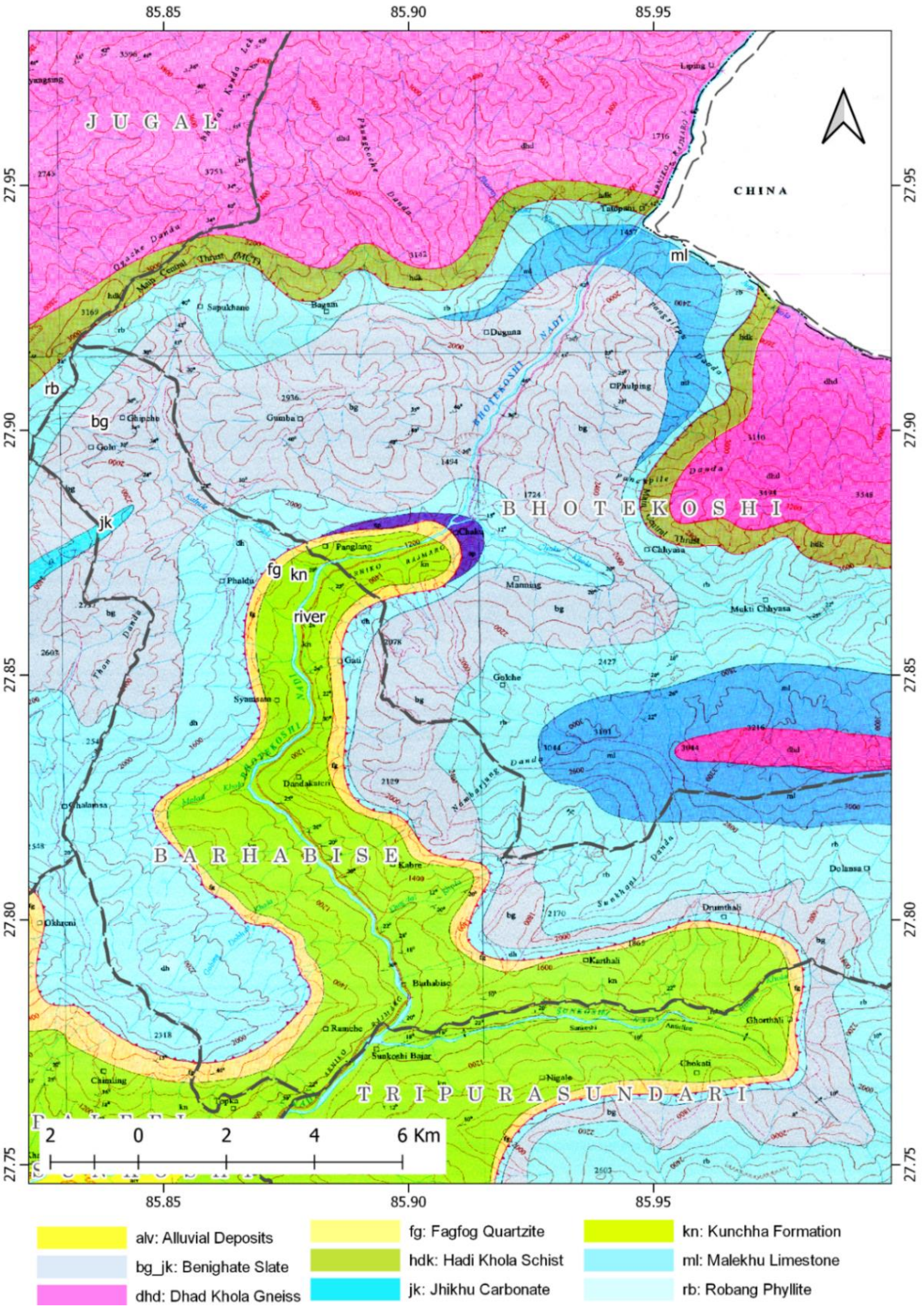


Figure 3-4. Geological map of the part of the Upper Bhote Koshi Valley covering the study area and its surroundings in the Bhote Koshi *Gaunpalika*. (Source: DMG, 2005).

SURFICIAL DEPOSITS: alv: **Alluvial Deposits**: Clay, silt, sand, gravel and conglomerates.

UPPER NUWAKOT GROUP (Pre-Cambrian): rb: **Robang Phyllite**: Chloritic-sericitic garnetiferous phyllite with thin intercalation of white quartzite and chloritic gneiss. || ml: **Malekhu Limestone**: Thinely bedded yellowish grey limestone with dolomite band. || bg(jk): **Benighate Slate**: Thinkely bedded, dark grey to black slate, grey phyllites, with bands of **Jhiku carbonate** (jk). || dh: **Dhading Dolomite**: Grey to dark grey thinely bedded dolomites and limestones, wikth thin intercalation of slate. || np: **Nourpul Formation**: Thinly bedded, pinkish phyllite with thin quartzite and dolomite.

LOWER NUWAKOT GROUP (Pre-Cambrian): fg: **Fagfog Quartzite**: Thinly bedded white line-grained quartzite with thin intercalation of slate. || kn: **Kunchha Formation**: Sericitic-chloritic green to grey, thinly bedded phyllite, tritty phyllites with thin intercalation of whige quartzite and amphibolities.

HIGHER HIMALAYAN GROUP (Pre-Cambrian) || hdk: **Hadi Khola Schist**: Thin to medium bedded, fine garnet-biotite schist, calc schist with thin layers of quartzite and gneiss bands. || dhd: **Dhad Khola Gneiss**: Porphyoroblastic gneiss, augen gneiss, with thin bands of quartzite and schists, magmatic gneiss.

According to the disaster data from the GoN BIPAD portal (2021) for the year 2020 (2076–2077 BS – the Nepali calendar is based on the Bikram Sambat, a widely used ancient calendar of the Hindu tradition that is approximately 56 years and 8 months ahead of the Common Era.), the total casualties due to different types of disaster included 558 fatalities (Figure 3-5), of which landslide covers about 54% of the total human lives lost due to disasters in Nepal. Sindhupalchok District was one of the most severely hit by the 2015 GE, and has been hit by associated landslides and floods in the years since (Liu et al., 2020; Rosser et al., 2021). The BKGP was among the areas that experienced the most severe impact from the 2015 GE, as shown in Figure 3-6(a) and (b). The 2015 GE triggered about 22,000 coseismic landslides that were distributed across 14 districts of Nepal, affecting over one-third of the country's entire area (Robinson et al., 2017; Roback et al., 2018; Williams et al., 2018; Kincey et al., 2020; Rosser et al., 2021). The majority of these coseismic landslides were shallow slope failures (Robinson et al., 2017). Importantly, this area, and that in which I conducted my research, was also the location of research on landslide hazards and risks carried out by Oven (2009), allowing me to add a longitudinal dimension to my own work.

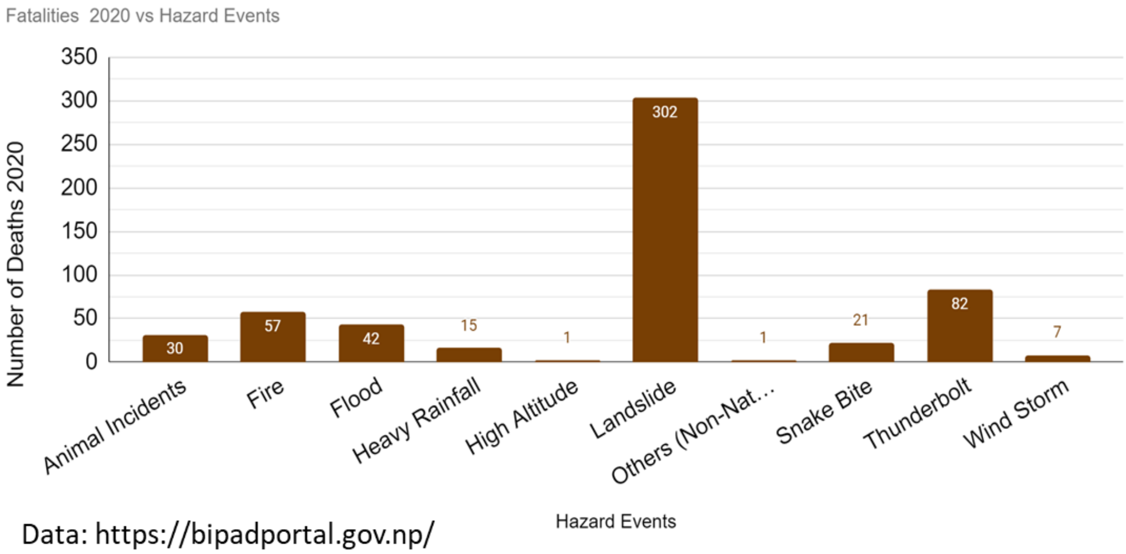


Figure 3-5. Deaths due to different types of disasters in Nepal in 2020. (Source: BIPAD Portal, 2021).

In the UBK, agriculture and livestock are the main livelihood options (Adhikari and Koshimizu, 2005; Jianqiang et al., 2016; Hussain et al., 2018). The UBK is settled by hill ethnic Tamang and Sherpa peoples of Tibeto-Burmese origin. In terms of caste and ethnicity, high-caste Hindus, Newars and occupational caste Kami, or blacksmiths, are dominant (Oven, 2009; Bhotekoshi Gaunpalika, 2019b). Out-migration due to the heightened landslide risk and limited opportunities as a result of the road closure left an estimated 70% of the full population during the time of the survey (personal communication with local residents). Many had moved away, including people who had previously lived near to the China–Nepal border crossing, which is a main national import hub and one of the highest revenue-collecting entry points in Nepal. The GHA (NRA, 2017a) identified some settlements in the BKGP that needed to be relocated due to unacceptably high landslide risk. Although I note that my study does not consider the GHA, because this was ongoing during my research, I do consider one of the communities identified as being in the 'red' category (to be relocated) in one of my PMEs.

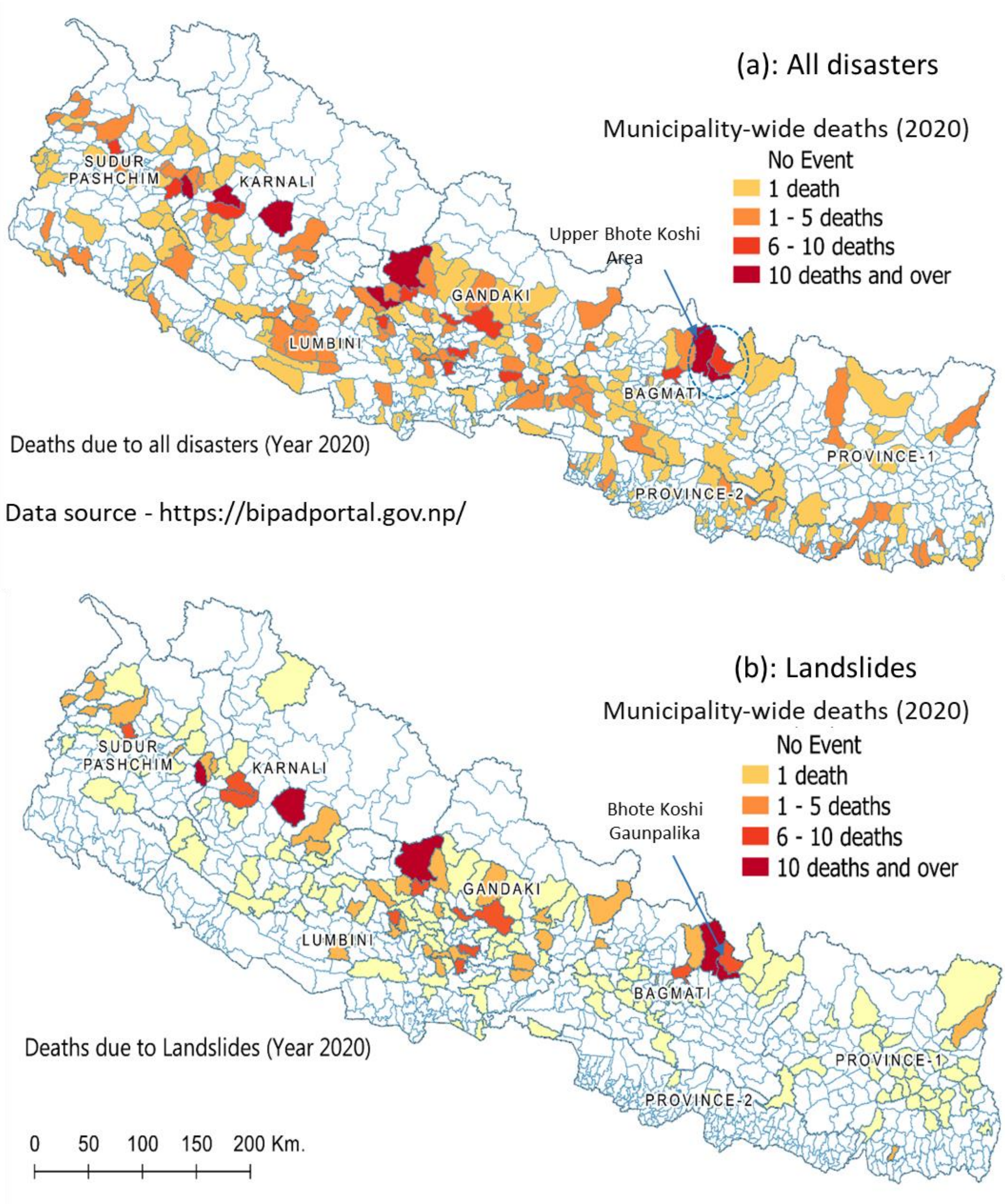
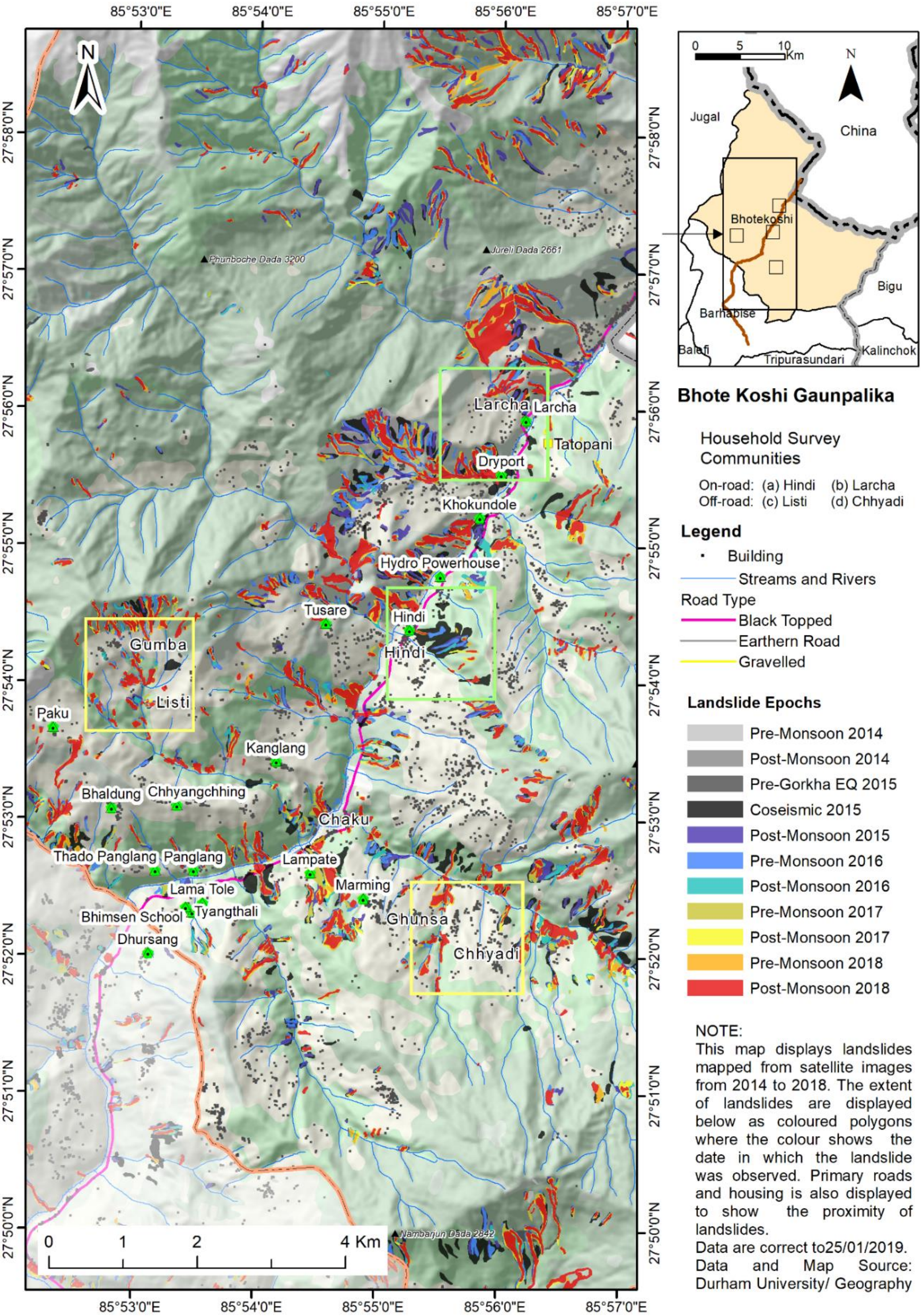
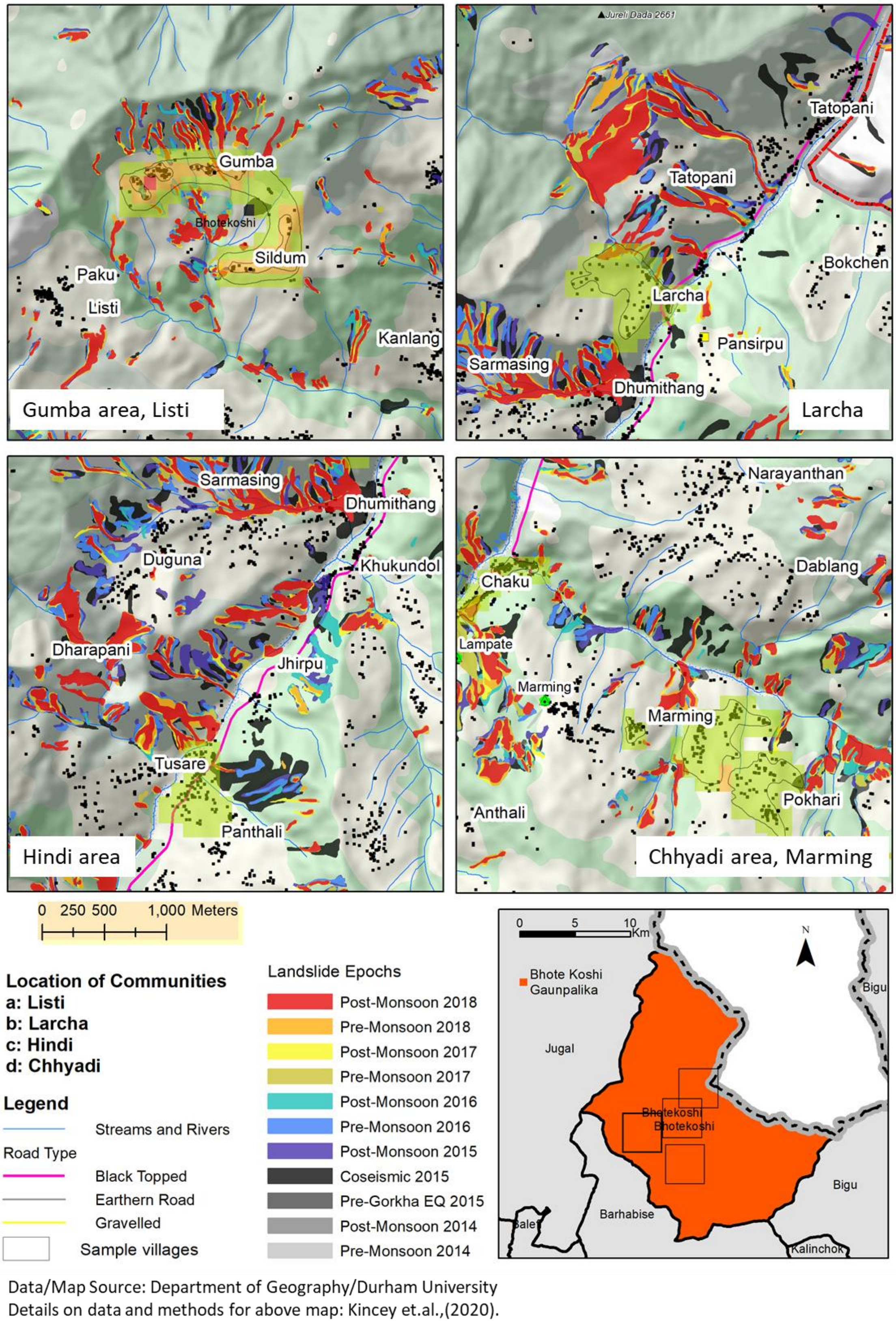


Figure 3-6. Map showing deaths due to disasters in Nepal in 2020 at *gaunpalika* level for (a) all recorded disaster events in the country, highlighting the Bhote Koshi *Gaunpalika*, and (b) deaths caused by landslides. Source: BIPAD Portal (2021).

The landslide hazards and risks that have emerged in the UBK in recent years, and the formal documentation shown in Figure 3-7(a) and (b), illustrate a complex pattern of overlapping events both before and after the 2015 GE (see Kincey et al., 2020). This reflects a situation of frequent recurring landslides, but also a significant step change in total landslide risk and in the style and scale of landslides people live near to, which inevitably influences how landslide risk is experienced locally by people in the valley (Figure 3-8).



(a) The case study communities in the Bhote Koshi *Gaunpalika*, with boxes highlighting Larcha and Hindi (on-road locations) along the Arniko Highway, and Listi and Marming (off-road locations).



(b) Four case study areas shown in detail, with mapped landslides. The distribution of buildings is shown as black dots, and the yellow areas highlight the case study communities.

Figure 3-7. Distribution of landslides (a) in the UBK, and (b) in the case study communities as rapidly evolved after the 2015 Gorkha earthquake. (Source: Department of Geography, Durham University).

Figure 3-8. Photographs showing glimpses of everyday extensive landslide events in the UBK that affect the daily life of the local people.

(a) subsided road section in the Hindi Narayanthan area, (b) overnight deposition of debris carried by the Chaku Khola filled a stretch of the Bhote Koshi river (June 2019) at Chaku, causing three human fatalities upstream near Chhyadi and damage to a hydroelectric power house in Chhyadi, (c) everyday local road obstruction due to overnight rainfall (Marming–Chaku section), poorly installed gabions damaged, (d) it was reported that a big boulder, near to Chhyadi village, could block the Chaku Khola, (e) deposition of large boulders near to Chhyadi, (f) landslides along a local road, obstructing necessary efforts to reopen it and (g) landslide on everyday walking trail used by local villagers from Fumache in the Larcha area.

3.2.2 On-road vs off-road communities

The settlements in my study area have many features characteristic of similar valleys in this part of the Himalaya. A significant influence has been the development of access and infrastructure, primarily through the growth of the road network. Roads have attracted settlement, providing livelihood opportunities in areas that have traditionally been largely dependent on subsistence agriculture. As a result, new on-road settlements can be quite different to older off-road settlements, both in terms of the people who live there, their houses and livelihoods, but also the hazards and risks they face. However, the two are far from being totally separate.

When evaluating on-road and off-road settlements in the UBK and along the Arniko Highway, it is necessary to understand the dynamics of the on-road settlements such as Chaku, Larcha, Tatopani and Kodari, which are the main local marketplaces in the *gaunpalika* (Table 3-1). Before the earthquake, these were highly populated areas with diverse ethnic and caste categories and in-migrant households (Oven, 2009). Pull factors associated with on-road locations are better economic opportunities, social services, health facilities and schools as compared with off-road locations. These are the major reasons for in-migration to on-road locations (Oven, 2009; Oven and Rigg, 2015). After the earthquake, the economic activities along roadside locations were heavily disrupted for a sustained period due to the highway being blocked and subsequently closed, which led to out-migration from the valley. In terms of landslides, most households in these locations face acute exposure because of their situation in the confined valley bottom, either at the base of steep and unstable slopes and channels, or along the banks of the river, which is prone to undercutting (Devkota et al., 2014) and frequent floods (Liu et al., 2020). The local population along roadside locations have often originated from the surrounding villages, and maintain links with their natal settlement. My on-road case study settlements for this research are Larcha and Hindi.

On the other hand, in off-road locations in the study area, householders are engaged in subsistence farming activities, with a majority having plots of land. The impact of out-migration is made visible by abandoned land. Commonly, it is the women, children and elderly people who have been left behind, especially after the earthquake (Tamang, 2020); younger men without skills have moved to Kathmandu or elsewhere and sought employment in the informal sector, for example, daily wage labour, or have become drivers or attendants (low paid *khalasi* or a handyman). The general sense of those remaining in the valley is that people will return if the international border with China reopens for trade, supporting the local economy. In addition, building works in the valley, such as road widening, reconstruction and maintenance of damaged/destroyed roads, and (re)construction of bridges and walking trails, require the engagement of the local population, which is essential to enable the valley's economic recovery. My off-road case study settlements are Listi and Marming.

Table 3-1. General characteristics of the on-road and off-road survey locations

Location characteristics	Communities: On-road and off-road	
	On-road (Larcha and Hindi)	Off-road (Listi and Marming)
Accessibility, connectivity to the location	Located along the national Arniko Highway. Post-earthquake disruption. Frequent flood and landslide events along the highway, disconnecting the valley.	Distant from the highway, frequent seasonal disruption to major roads, frequent disruption of local/rural roads and walking trails connected to the main highway.
Livelihood	Mixed livelihood. A variety of local shops, including grocery shops, serve local villages, which are often connected to other villages in the valley by family ties and trade. Badly damaged livelihoods and infrastructure due to the 2015 Gorkha earthquake.	Farming activities, income from remittances (both in-country and out-country). Previously engaged in border area activities such as trading. Income is commonly day wage labour. Farm-based, badly damaged livelihoods due to the 2015 Gorkha earthquake.
Local vs in-migrant	Residents are of mixed origin from both inside and outside the valley. The majority of residents were from the surrounding villages at the time of the survey.	Commonly a homogenous population in a *tole* or village, with multiple generations living in these locations.
Village demographies	Local businesses restarted about three years after the earthquake when the border with China was reopened. The majority of the working-age population live in on-road locations.	Out-migration of many young working-age men, leaving women and older populations as permanent residents; however, the active community returns to the valley for cultural and family visits.
Primary source of household income	Grocery shops, tea shops, local businesses, pharmacies, bakeries, etc.	Remittances. Subsistence farming for household purposes, typified by low productivity.
Caste/ethnicity	Mixed, coming from surrounding hill/ethnic groups and outside the valley.	Homogenous, majority are the hill ethnic groups Sherpa and Tamang.

(Source: Gaunpalika profile (Bhotekoshi Gaunpalika, 2019a, 2019b), Oven, 2009, Oven and Rigg, 2015 and Oven et al., 2021).

Figures 3-9 and 3-10 show an overview of the landslide hazard scenario in relation to the locations of the case study communities in the UBK, with perspective photographs.

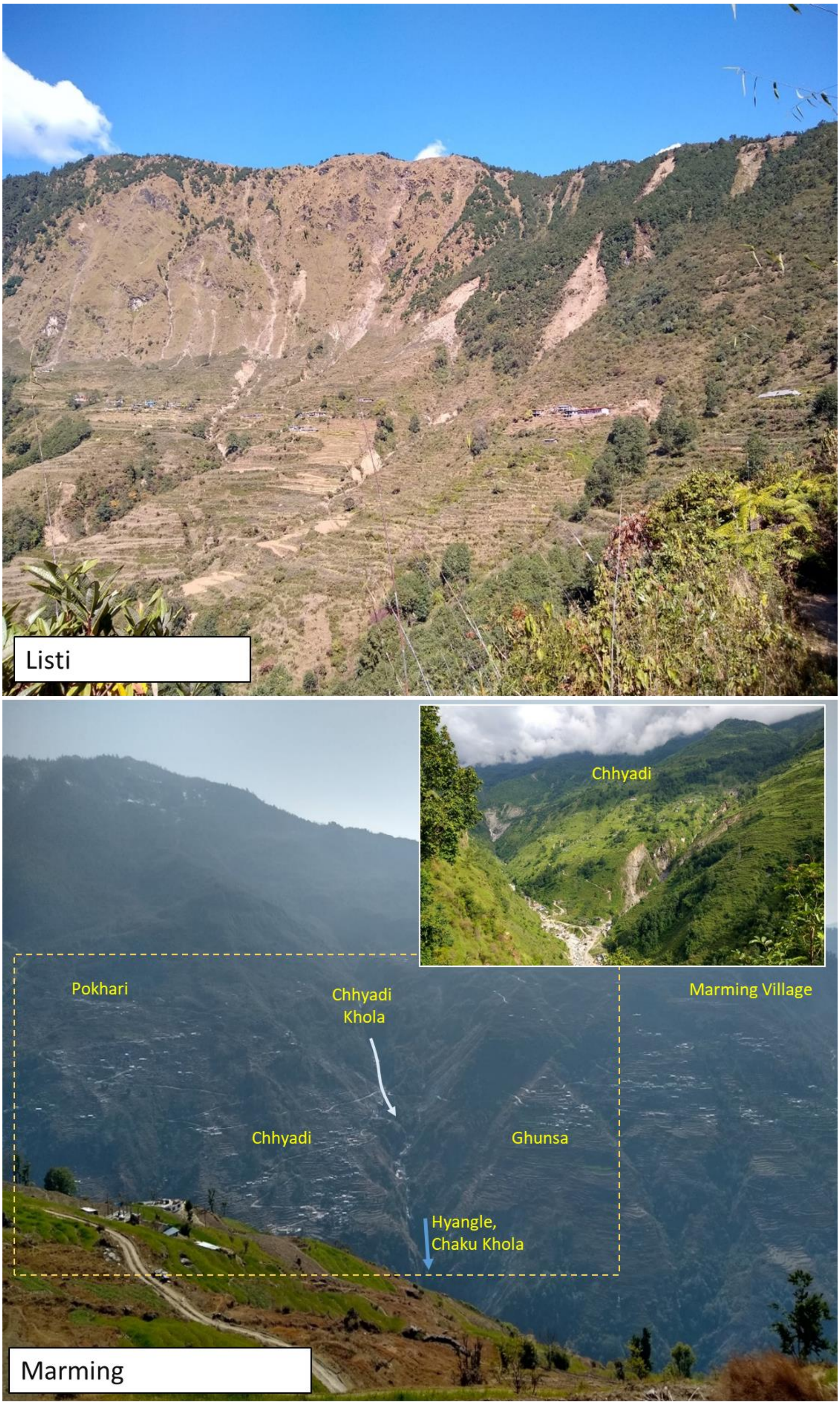


Figure 3-9. Glimpse of two off-road communities located on the mid-slope of a hill in the Upper Bhote Koshi Valley.

Figure 3-10. View of Hindi area located along the Arniko Highway showing the local hazardscape. The area within the black dots is a slow-moving landslide that emerged after the 2015 earthquake.

3.3 Review of methods used to assess local understandings of landslide hazards and risks

Various quantitative and qualitative methods have been employed to study local understandings of natural hazards and the associated risk perceptions. Quantitative approaches mostly follow psychometric research paradigms (Slovic and Weber, 2002), whereas qualitative approaches are more rooted in cultural research (Xu et al., 2016). Quantitative methods for studying risk perception (local understandings) rely on measuring variables by utilising questionnaire surveys based on ratings, rankings or similar (Xu et al., 2016). These surveys typically target specific groups at the household, community or national level (Ho et al., 2008). At the same time, qualitative methods aim to conduct in-depth analyses of the respondents' experiences (Covey, 2001).

Several examples of qualitative methods for assessing risk perception are available from a range of literature on landslide hazards and risks (Finlay and Fell, 1997; Calvello et al., 2016; Landeros-Mugica et al., 2016; Calvello, 2017; Hernández-Moreno and Alcántara-Ayala, 2017). Qualitative methods for studying landslide risk perception are relatively popular from a social science and cultural perspective (Xu et al., 2016), and usually include participant observation, focus group discussions, an exploration of life histories and interviews, as well as formal and informal conversations among stakeholders (Pilgrim, 1999; Oven, 2009; Halvorson and Parker Hamilton, 2010). Qualitative methods enable the researcher to go beyond yes/no answers and is an approach that is applicable in cases in which there is less opportunity for collecting information using questionnaire methods and in which the research requires an in-depth exploration of respondents' views (Bjønness, 1986; Gurung, 1989; Pilgrim, 1999; Dahal and Hagelman, 2011).

The use of mixed methods for investigating the perceived risk of landslides blends both qualitative and quantitative methods to develop approaches that utilise numerical analysis, but also aim to give a more nuanced view of the given social context (Dunn et al., 2011; Gaillard et al., 2016). Thus, the mixed-methods approach combines data collected from formal questionnaire surveys with secondary information, such as qualitative detail from semi-structured interviews, focus group discussions and spoken narratives, to elicit detailed information on risk perception held by individuals, households and wider communities (Gurung, 1989; Palinkas, 2006; Creswell and Plano Clark, 2007; Landeros-Mugica et al., 2016; Sullivan-Wiley and Gianotti, 2017). There is no standard method for assessing community landslide risk perception; however, the mixed methods approach is widely used both because it is practical and with adjustment can be suitable in most contexts (Calvello et al., 2016; Gravina et al., 2017; Thiene et al., 2017; Qasim and Qasim, 2020). Critically, this approach includes the community itself as an integral part of the knowledge (co-)production and exchange processes, which echoes the ethos of my research design.

Despite the popularity, benefits and 'complementary strengths' (Johnson et al., 2007) of the mixed-methods approach, it has some challenges that require expertise when collecting and analysing data. The practical problem of the knowledge gained using mixed methods can appear in terms of disparate results due to the distinct nature of the different types of data, which can make integrating two sets of very different data challenging (Creswell and Plano Clark, 2007). When qualitative and quantitative data are being analysed and compared, they require careful consideration (Ivankova et al., 2006). Johnson et al. (2007) suggest applying contingency theory to help researchers make decisions when mixing two methods and approaches to maximise the usefulness of information and evidence collected.

Many researchers have undertaken one-off risk perception studies for a range of geophysical and hydro-meteorological hazards; few studies capture longitudinal perspectives for landslide hazards and risks for which the exposure, hazard or vulnerability has changed. As such, only a few studies have focused on the changing understandings of landslide hazards and risks at the local level, which is surprising given the rapid rate of change in many rural areas of developing mountainous countries. As a result, there remains a gap in the evaluation of local understandings, especially the change in risk perception after a high-magnitude hazard compared with that before the event, or how such events compare with day-to-day lived experiences of landslide risk. Therefore, studying local people's risk perception is vital for understanding their decision-making processes, which adjust both their behaviour according to the hazard situation and their willingness to contribute to the mitigation efforts (Slovic, 1987; O'Neill, 2004; Dahal and Hagelman, 2011).

3.4 Methodological approach

In this section, I give a short summary of the overall design of my research methodology. Community understandings play a vital role in successfully implementing and sustaining community-based approaches for risk reduction (Oven et al., 2017; Oven and Bankoff, 2020). Identifying potential initiatives that could be adopted by householders and communities to reduce disaster risk often relies on such insights as a starting point (Lindell and Perry, 2012). As a result, several methods for appraising perceptions have been developed, as summarised by Kellens et al. (2013), reflecting the development of work on risk perception during recent decades. People's perceptions influence priorities and preferences when identifying and adopting different risk reduction approaches, and they are vital in appropriately assessing the potential usefulness of any planned intervention in a given socio-economic and cultural context, such as the mountainous areas of Nepal.

A broad mixed-methods approach has been adopted for my research (Ivankova et al., 2006; Palinkas, 2006; Creswell and Plano Clark, 2007; Lund, 2012; Alam, 2020). In this, I seek to combine an appraisal of the understandings of landslide hazards and risks at both the household and community level. To explore local understandings of landslide hazards and risks, people living in two separate locations, off-road and on-road, were invited to be participants in my research. These two broad communities typify the majority of the mountain social landscape of Nepal, being located around valley walls and hilltops, and along the rivers and highways of the UBK. This research drew upon the benefits of both semi-quantitative (i.e. survey questionnaires) and qualitative (i.e. semi-structured, open-ended questions and PMEs) techniques, the results of which were used to develop a new live demonstration for communicating information on landslide risk, as described in Figure 3-11.

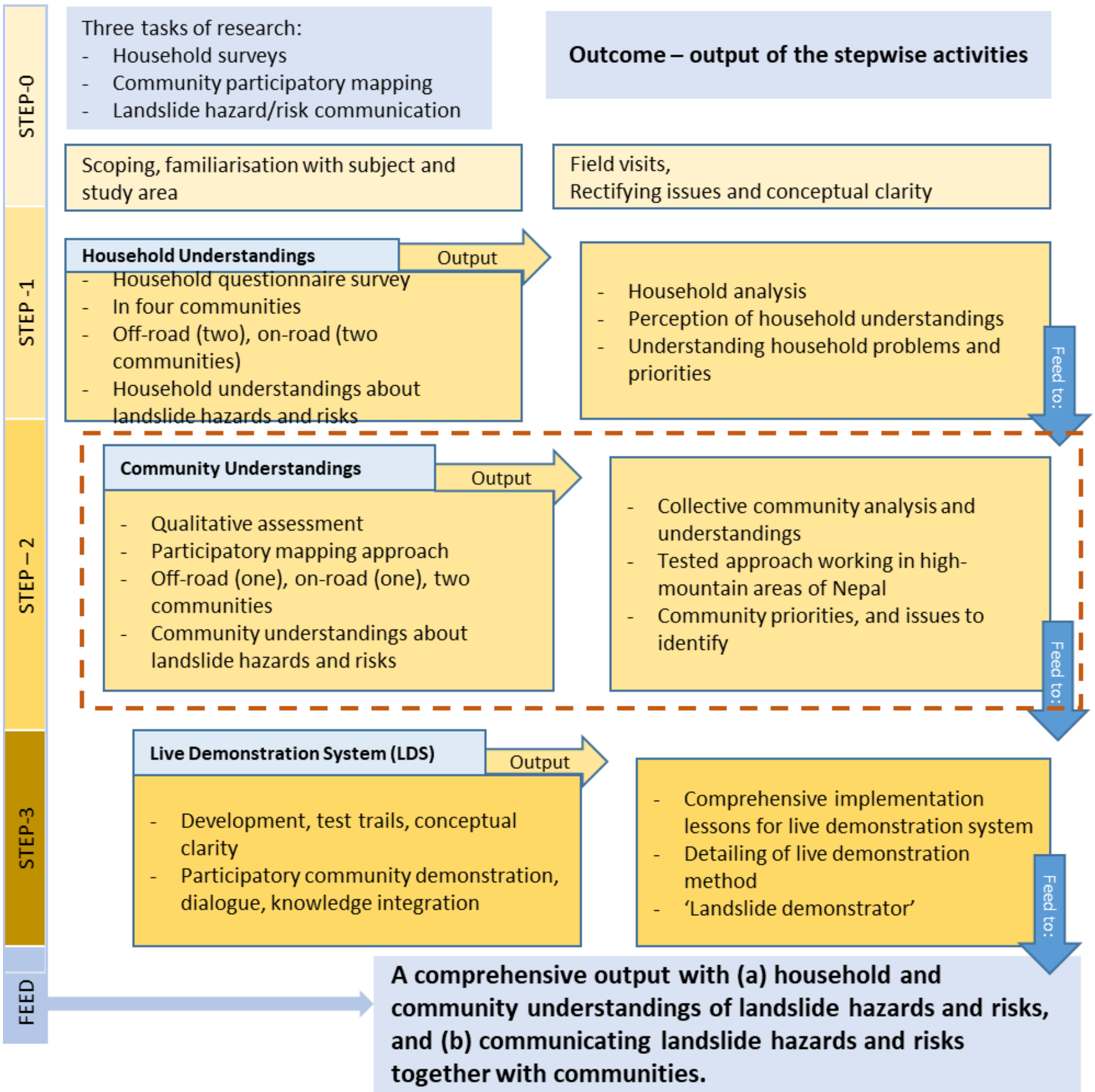


Figure 3-11. A generalised workflow of the research process showing the different tasks and results for each of the research steps.

The mixed-methods approach allowed me to gather data, make cross-references and use triangulation to confirm the results when seeking more robust evidence than either qualitative or semi-quantitative approaches could provide alone. In this study, a mixed methods approach also provided a means of evaluating both individual householder and community understandings, views and experiences in a structured way, which allowed me to consider more effectively how these manifest themselves (Gaillard et al., 2016). This type of approach emphasises the dialogue between different stakeholder groups such as local people, NGOs, government agencies and scientists, who seldom otherwise directly discuss local strategies for DRR (Gaillard et al., 2016). As such, an intention of my research strategy is to provide opportunities for new discussions about landslides by integrating the benefits of both qualitative and quantitative approaches (Dunn et al., 2011; Lane et al., 2011; Gaillard et al., 2016).

A mixed-methods approach can be applied in either a sequential, concurrent or transformative manner (Ivankova et al., 2006; Creswell and Plano Clark, 2007), according to each one's suitability for the research strategy and its aims. I focus primarily on a sequential procedure (Ivankova et al., 2006), applied from the design of the research to implementation of the fieldwork. Theoretically, the sequential process can be started with one method, and then at each step, the method can be expanded or changed, based on the findings from each step as they progress. Therefore, the researcher can begin with quantitative data collection and analysis, and then subsequently, he/she can collect and analyse qualitative data or vice versa (Lund, 2012), depending on which interesting threads or themes emerge progressively from the data (Covey, 2001; Wanasolo, 2012). In this light, I first began collecting household data with my survey, then conducted PMEs to focus on emerging issues. The following third step focused on interactive demonstrations of the landslide model, and built on the learning from the earlier steps.

3.4.1 Scoping study and initial identification of key local issues – Step 0

In this stage (Step 0), I aimed to introduce myself to the field area, and the case study communities in particular. The main aim of the scoping visit was familiarisation, and the identification of key local issues. This is seen as an important step for developing mutual trust with communities who are potentially going to be participating in the research, and gaining their confidence (Jigyasu, 2002; Dekens, 2007; Wanasolo, 2012; Banks and Scheyvens, 2014; Haworth et al., 2016; Cieslik et al., 2019; Oven and Bankoff, 2020). As well as introducing myself to the representatives of local authorities, I also aimed to build rapport with potential participants and to use this experience to inform the design of the more detailed fieldwork to follow.

During this time, in October 2017 and June 2018, I held a series of informal consultations with local stakeholders, including teachers, community members, *gaunpalika* officials (locally elected officials and government officers) and members of local CBOs such as women's groups. This was a fundamental step towards broadening my knowledge of the area, understanding key local issues and politics and developing important local contacts. This step was also very helpful in refining my research questions, in particular, ensuring they were locally relevant while narrowing down my site selection for the research.

3.4.2 Household survey – Step 1

This step (Figure 3-11) of the fieldwork was based on a household survey in the case study communities to assess local understandings of hazards and risks in general, and landslide hazards and risks in the post-2015 GE context in particular. The survey addressed research questions 1, 2 and 3, concerning household and community understandings of hazards and risks in the changing context of the aftermath of the 2015 GE.

During a six-week fieldwork period between October and December 2018, a quantitative household survey was conducted by visiting a sample of households in each settlement (Figure 3-12). The household survey initially planned to capture data from *c*.200 households across the four communities.

Figure 3-12. Household survey in progress in the case study villages in the UBK, 2018.

After selecting communities for the survey, I delineated the extent of the area to be surveyed that would constitute each community. These communities belong to ward-level settlements (the lowest unit level of administration/governance in Nepal). I first consulted with village representatives to estimate the total number of houses or families living in that ward or settlement. My plan was to visit a total of 200 households for the survey, that is, 50 households from each community. Ultimately, due to limitations in recruiting participants, a total of 168 households were surveyed. After an approximate number of families were defined, I sampled every (for example) fifth household while walking through the village. As the settlement size varied, the sampling rate varied accordingly.

The challenges of selecting householders as respondents were various. The survey was conducted in the context of transition from the old to the new administrative (local government) structure. Because of this transition, official information and local government data were almost nonexistent. For example, there was no official data on the total number of householders, and historical data was inaccurate because many households had left the area since the 2015 GE. As a result, a degree of flexibility based on judgement was needed in the field to ensure the best sample size was obtained without introducing any inherent bias into my data. In cases in which the approach of counting residences, or relying on village data was not applicable, decisions were made on site in consultation with community representatives to select which households to engage in the survey.

In the case of multiple households living in a single house, only one family was chosen for the survey. This possibility was expected to occur in the on-road settlements, where the chances of multiple families living in a single house are more common. It was recommended that to begin with, research assistants, who helped implement the survey, spoke with the household head, or the next most senior adult member of the family. The survey's explicit definition of 'household' and 'family' applies interchangeably in rural communities in Nepal, such as those studied. Furthermore, conversations with householders and locals before and after the survey provided an excellent opportunity for understanding the local context and triangulating the information in more detail.

3.4.3 PMEs – Step 2

Step 2 (Figure 3-11) was designed to assess understandings of landslide hazards and risks using PMEs. This process was intended to address research questions 1, 2 and 3 (Section 1.4), which focus on household and community understandings of these issues in the changing context of the aftermath of the 2015 GE. In this second phase of my research, conducted between July and September 2019, I developed a participatory mapping approach, which was undertaken in two out of the four case study settlements (Larcha and Marming). The PME participants were a diverse group of villagers, with 4–10 people in each group (Figure 3-13). The PMEs aimed to map concerns and key local issues associated with landslide hazards and risks (Section 5.3.3). The exercise was supplemented by discussions guided by a common set of questions (Appendix 1).

Figure 3-13. Glimpses of participatory mapping exercises in communities.

As a research tool, my PMEs were designed based on lessons learned from earlier research in this field (Chambers, 2006; Mercer et al., 2008; Gaillard and Maceda, 2009; Rambaldi, 2010; Cadag and Gaillard, 2012; Gaillard et al., 2013; Reichel and Frömming, 2014; Klonner et al., 2018; Oven et al., 2021). PMEs as a method has become increasingly popular; their strength lies in bringing local people and researchers together, drawing on their knowledge to share experiences and build common understandings (Mercer et al., 2008; Brodie and Cowling, 2010; Rambaldi, 2010). I aimed to explore both spatial and non-spatial understandings among participants that reflected social networks, knowledge of local landscapes and locally experienced mental mapping of risks (Brodie and Cowling, 2010). This exercise aimed to focus on everyday problems such as those associated with the daily commute to school, trips to the market, household- or family-related visits, or similar. Despite having clear benefits for research, PMEs are often criticised, because the process tends to be facilitated by 'outsiders' or conducted by 'educated' people, who research and create knowledge that, ultimately, is 'extracted' (Chambers, 2006, pp. 2–3). This issue raises the question of ownership and the influence of external actors in the process, which I have been mindful of in the design and implementation of this part of my research. The outcome of this part of the research provided the fundamental basis for designing a new landslide risk communication tool.

3.4.4 Communicating information on landslide hazards and risks using a physical model – Step 3

Step 3 (Figure 3-11) describes the development of a novel tool for communicating information on landslide hazards and risks to communities through the medium of a live demonstration. This part of my research sought to build on Steps 1 and 2, and to tackle emergent knowledge gaps in relation to landslide hazards and risks, with the overarching aim of meeting the objective of research question 4, that is, improving the communication of information concerning landslide hazards and risks.

This approach developed from the concept of participatory three-dimensional (3D) modelling (Wagner, 2007; Gaillard and Maceda, 2009; Rambaldi, 2010; Cadag and Gaillard, 2012). I focused on presenting a visual and engaging demonstration of landslide mechanisms that lead to the generation of hazards and risks (Figure 3-15), building squarely on the idea that 'seeing is believing' (Andrea and Michael, 2004). The approach builds on an already successful DRR demonstration, namely, the shake table, which was created by my employer NSET in Nepal (Jimee et al., 2012; Upadhyay et al., 2012; Dixit, 2014). The shake table model simplifies and reduces the scale of the type of shake table commonly used in seismic engineering research, and provides a vivid live demonstration that is tailored to show clearly the benefits of risk reduction measures, for example, low-cost structural features to strengthen typical buildings in Nepal. Here, I seek to emulate this approach, but focusing specifically on landslides. Based on the experience of the shake table demonstration, the following priorities helped in the design of the approach: (a) a clear explanation of the concept or idea; and (b) an attempt to deepen community knowledge by striking a balance between science and local experience and providing a demonstration of tangible and actionable measures that the community can take.

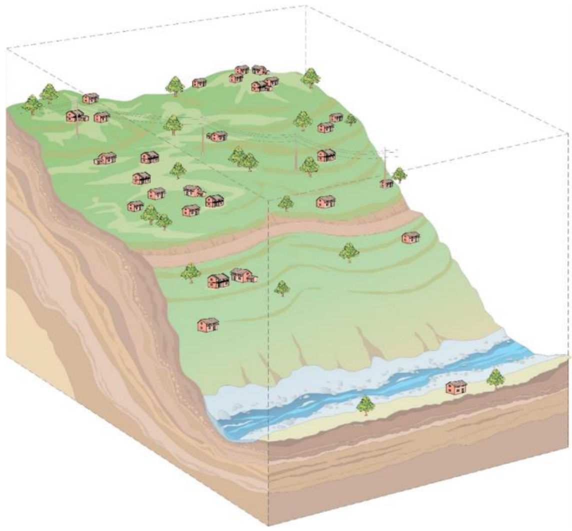


Figure 3-14. A conceptual schematic overview of a typical Nepali landscape to be replicated using the landslide demonstrator, showing typical features such as the river, steep valley walls, dispersed houses and unstable road cuts. (Drawing by: C. Ranamagar, NSET).

Figure 3-15. A common representative real landscape (here, Chhyadi village area, showing community buildings, local roads, schools, farmland, scattered settlement patterns, electricity poles, etc.) used as the basis for the approximate replication of the local landscape and features in the model as shown in Figure 3-14. (Source: Google Earth).

It was originally proposed that the landslide demonstrator should be placed on a tipper truck vehicle, which would have allowed for easy transportation and a relatively large scale of model. Due to the complicated logistics of this scale of approach and the need to first trial and test the models at a smaller scale (e.g. *c.*1 x 0.5 m), the present model, which itself underwent several iterations and improvements, was adopted for this research, as described in Chapter 6. The demonstrator is intended to develop knowledge exchange between the community and those running the demonstration according to three basic elements: (a) the nature and characteristics of landslide hazards and risks faced by communities; (b) changing hazards and risks over time, focusing primarily on small or everyday events; and (c) an exploration of what is feasible in terms of mitigation options that are actionable, for example, relocation, physical mitigation measures or early warning systems.

3.4.5 My own positionality

Positionality has a vital role in social science research, notably in shaping how participants perceive individual researchers (Skelton, 2001). Positionality concerns a number of factors such as age, gender, ethnicity, culture, race, class, education and the ability to coordinate people in different socio-cultural circumstances. It also involves sharing experiences of how we as researchers undertake our work in and with communities (Merriam et al., 2000; Skelton, 2001; Manohar et al., 2017). These factors represent a person who is a researcher, defining who he/she is and how his/her identity has been formed (Skelton, 2001), potentially shaping participants' responses. In addition, the emotional and political context of the places where the research is being conducted influences community views towards the researcher. Therefore, all these factors have an effect on the data collected and the eventual outcome.

A researcher's status, for example, whether he/she feels he/she is or is perceived as an insider as opposed to an outsider, is also a vital element for the success of any research in which participants 'place' the researchers, and vice versa (Manohar et al., 2017). As a Nepali, my positionality lends itself to that of an insider as opposed to an outsider, but this had both advantages and limitations. I am identifiable from my name/ethnicity as likely to be of the Brahman caste, which is probably a different caste from many of my participants. In Nepal, Brahman is regarded as a high caste, which in the eyes of my research participants may lead to assumptions about particular values, characteristics and stereotypes that I may fit. I was very mindful of this context when conducting my field research. I grew up in Syangja in Western Nepal, which faces landslide issues similar to those in my study site. During my early years, I regularly encountered landslides, for example, during my one-and-a-half-hour commute to school, and I saw what steps the community took to manage the risks these posed. As a researcher, if I were to place myself within the insider category based on sharing cultural similarities, I would have the privilege of easy and quick access to the community (Merriam et al., 2000, 2001), and perhaps their psyche. As a Nepali researcher, my positionality in this research was arguably as a 'peripheral insider' (Figure 3-16); however, this was not without problems. The 'interlocking nature of culture, gender and power' implies gaps and overlaps when conducting fieldwork, especially for an outsider (Merriam et al., 2001, p. 409). Merriam et al. (2001,

p. 409) observe that cultural understandings take place through 'language, proverbs, and non-verbal expressions' when conveying the meaning of messages to the researcher.

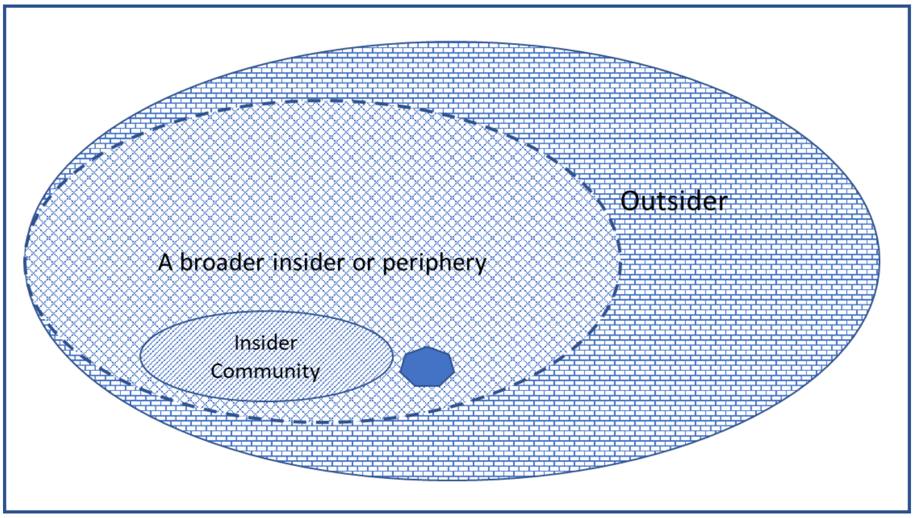


Figure 3-16. Schematic diagram showing my positionality as a researcher in relation to outsider versus insider.

Despite being an insider, I do not originate from the study area (UBK). I was born and grew up about 150 km to the west. In addition, I was educated in different towns, worked in Kathmandu and then travelled for education overseas, all of which made me peripheral, even though I speak and write Nepali, which enables me to communicate very well with villagers and understand and share similar ritual and cultural values. Thus, although I was continuously aware that the community might receive me as an insider, 'unless one actually lives in a particular village or town, s/he is somewhat of an outsider to the community' (Merriam et al., 2001, p. 410):

> It has commonly been assumed that being an insider means easy access, the ability to ask more meaningful questions and read non-verbal cues, and most importantly, be able to project a more truthful, authentic understanding of the culture under study. On the other hand, insiders have been accused of being inherently biased and too close to the culture to be curious enough to raise provocative questions.
> (Merriam et al., 2001, p. 411)

The practical challenges relating to my positionality during fieldwork, as Merriam et al. (2001) observed, suggested that to some extent I already knew the (likely) village situation, which often led to participants saying, 'you already know', 'you should know' or 'see there because you are within us'. This put pressure on me to understand fully what was important about the local context in cases in which local dialects or cultures differed significantly from my own. In many cases, conversations between insiders do not commonly involve elaborations on the context, so I often had to request further explanation or ask follow-up questions that burdened my respondents and interrupted the flow of the conversation. Therefore, in my dilemma of being an inside-outsider or an outside-insider (someone on the periphery), my interpretations are based on those responses community members willingly shared with me.

One key factor of my research that was important in tackling this issue, was that mine was not a one-off survey, but a continuous and relatively long-term engagement involving multiple visits. By the end of the research, I came to understand that I was a familiar face in the valley, and many knew my name and what my research interest was, which I felt helped enormously. In various consecutive visits to the area for my research work and in my ongoing engagement with the case study communities across all three parts of my research, I felt a moral pressure to maintain the trust I had established with these communities. I noted that especially during the development of the landslide demonstrator (Chapter 6), my researcher status overlapped with that of an expert standing in front of the community, which was both a new and uncomfortable role to play. Still, my aim was to build on the trust that I had established to make these latter engagements possible in the first place, and then effective and fruitful.

3.4.6 Building trust

Because it is widely recommended as the first step to take before the beginning of any formal intervention (Oven, 2009; Michoud et al., 2013), my first focus was on building trust with local communities and gaining their confidence. My introduction to the UBK area began after the 2015 GE, when I started working with Durham University on research concerning landslide monitoring and the observation of changes in ground deformation that were a result of the earthquake shaking. This was a privilege for me, being able to introduce myself to communities, and meeting and working with local people in the UBK. I was often entrusted with being the public face of the research, engaging with communities and requesting their observations and guidance on various matters, for example, where to position landslide monitoring equipment. This put me in a comfortable situation in which I was able to familiarise myself with the local communities and exchange ideas about landslide hazards and risks in the area. During many subsequent visits, I also had the opportunity to meet local communities, teachers, ward officials, local representatives and many others, and build a rapport with them, which allowed me to enrich my knowledge about the issues and areas of concern. Introducing my supervisory team formally to the area during various visits also helped me to reflect on different views of the local hazard context, from formal hazard mapping to widening my links to include other key people in the area.

I adopted a joint top-down and bottom-up approach to my research (Johnson et al., 2007), gaining access to households and communities by different methods, and enhancing what I viewed as my partnership with the community (Wilderman et al., 2004). I started my research by introducing myself to the *gaunpalika* authority with a formal request for access to the communities.

(Appendix 3). I submitted formal letters, and had meetings with municipal officials at the municipal head office and meetings with ward chairs and ward officials in their respective wards, with the intention of building a rapport with them, as is customary in Nepal. Likewise, when familiarising myself with the local area, I met local community members including teachers, local representatives and shopkeepers in person, and sought their cooperation in my research. In this way, I developed a rapport with them too, gaining their confidence and trust. During my fieldwork, I was invited to attend some of the formal meetings in the *gaunpalika*, both to observe and also to offer insight from my own perspective. I participated in some events, especially in *gaunpalika* council meetings in which yearly budgetary decisions and planning were discussed. In this sense, based primarily on these long-term interactions, I believe I was successful in building trust with the community and gaining their respect. In addition, these opportunities for participation in local life helped me gain recognition for my research from the local authority, and added considerable value in that they broadened my knowledge of the local context.

Village ceremonies were other opportunities for observing the local cultural practices of note. Although I had no direct intention of celebrating such events, it was customary to attend when invited, so these opportunities were incredibly valuable. Again, I took the opportunity to meet with ward chairs in person, women's groups, youth club members and staff from local police stations to gain different perspectives on my topic of interest. These interactions developed a good foundation for obtaining knowledge but, critically, they were important in building trust with the communities, gaining their confidence and also creating transparency, so there were no suspicions about my motives.

However, as often happens when conducting research in local communities, participants are more likely to respond to questions they think the researcher wants to hear the answers to (Lavers, 2007), which is something that I encountered. Moreover, responses can be distorted by local people's views, based on their anticipation that 'the researcher might be able to deliver' something of benefit in the future (Oven, 2009). Mitigating such an impression is also a challenge for the researcher, particularly in the Nepali context in which communities may often have expectations of external visitors in disaster-prone areas where external support is an increasingly common part of community life (Karkee and Comfort, 2016). When I travelled and worked with colleagues from overseas, it was clear community members expected investment because they thought I was from a NGO or represented a donor agency. For example, when I requested an appointment with a local elected representative, even before the consultation started, he asked what benefit there would be to the community if I did my research in the area. Another ward chair was quite dismissive when he shared his experience with other NGOs, and was quite critical of previous projects. For him, every outsider who came to the village was from a NGO, and he branded me with his assumed stereotype of a NGO worker. It took some time to explain my student status, but he later became one of my best friends at the field site. Such experiences were common, and could only be mitigated by being open and transparent to build trust so that I could carry out the research effectively.

In some cases, having apparently multiple identities (an earlier introduction working for NSET, and later as a student) posed difficulties and challenges for me. I clearly explained that my studies at Durham University were intended to support local authorities and communities in relation to landslide DRR initiatives, including awareness-raising activities in their villages. I clarified for the participants that this was purely academic research and was not linked with any government body or NGO. Such expectations are common in relation to many CBOs and NGOs that are active in working with communities. My ultimate motto in relation to the community was obviously 'do no harm'; however, we can never know the full consequences of our actions (Kellehaer, 2002; IFRC, 2020).

A further issue in relation to open-ended questions asked during the household survey, for example, my request for householders to explain their contributions to risk mitigation, was that they touched on clear sensitivities concerning responsibility. As a result, certain responses were guarded during all phases of my field research, and I became increasingly mindful of describing and explaining my purpose, the longer-term intended outcomes and, hopefully, the benefits to help tackle the reticence. My overriding aims in this context were to explain my position clearly, be transparent and to limit the scope of my work so that it was understandable.

3.4.7 Research permission and establishing local contacts

It was necessary to complete the formal process for gaining permission to conduct research in the BKGP, and a letter requesting permission was submitted to the *gaunpalika* office to arrange appointments with the chairperson and executive officer. In these meetings, I introduced myself, explained the aims and objectives of my research and offered to answer any questions the authorities may have had. As the local authority, the *gaunpalika* has the responsibility for issuing letters allowing research work to be carried out within their jurisdiction. This letter facilitated direct access to local networks and enabled me to approach local villagers, local representatives, teachers, ward chairs and local ward offices. Although there was no assigned gatekeeper working on my behalf, I was then able to use these local networks as my primary contacts for any help needed during fieldwork. Community-level (village) permission was requested before beginning my work by visiting ward chairs to ensure that I confirmed the permission granted by the *gaunpalika*. In each subsequent fieldwork phase, I provided in-person updates to the *gaunpalika* office explaining any concerns or asking for assistance if required.

3.4.8 Matters related to consent

I followed a standard protocol for gaining consent from my participants. When designing my research, I submitted my plan to the Department of Geography Ethics Committee at Durham University for approval. An information sheet and consent letter describing the purpose, duration and nature of the research (see Appendix 4 (information sheet) and Appendix 5 (consent form)) were prepared in open and accessible language for the participants in Nepal. Verbal informed consent was obtained from each respondent before the research started. Each participant was provided with an explanation of the research objectives, and informed about the voluntary nature of their participation and the fact that they could withdraw from the process at any point if they were not willing to continue. In group exercises, the same strategy was used with a verbal explanation before starting the activities, recording the permissions granted.

There are generally challenges associated with limited levels of literacy in village settings in Nepal, especially in cases in which written consent is required. Most participants in my study area were non-literate or unable to read and write formal documents. As such, gaining written permission or consent was inappropriate and not convenient. It was uncomfortable asking villagers for their signature or thumbprint, particularly when people were hesitant to sign any document that they could not read or understand themselves. Therefore, following the recommendations of Banks and Scheyvens (2014) and Scheyvens (2014), verbal consent was felt to be the most appropriate way of obtaining consent in such a socio-cultural context. I would sit down with potential participants, introduce myself, explain the purpose of the survey and ask for consent verbally (Oven, 2009). To support this, I used a checklist to confirm what I had said and asked, and indicated on my survey sheets that consent had been granted.

As a Nepali researcher, I was also aware that people might not want to share local community issues with an outsider, which was something I encountered in Lampate. In part, this was rooted in a concern about where the information offered might end up in the future and its potential to make trouble for the community. To counter this, I fully acknowledged my responsibility and assured my respondents they would be granted anonymity, emphasising that the sole purpose of my activities was research to enhance knowledge. I adopted a standard confidentiality practice, which is about protecting participants' identity (Valentine, 2005). This practice only records non-personal information to describe respondents' responses and opinions, for example, age, gender, ethnicity, profession or affiliation. Any names used in this thesis are quoted with permission, or refer to the codes or pseudonyms assigned to protect individual respondents' identity. Photographs were taken and audio and video recordings made as appropriate, with the permission of individuals and groups during the household survey and PMEs. Participants were told the reason for this type of recording, and it was fully explained before the meeting started that any information gathered in this way was to be used only for the purposes of research.

3.4.9 Language

The fieldwork was conducted in my native Nepali, which required careful translation of technical or academic English words that often have no direct equivalent (e.g. resilience). Because the people in the off-road locations were mostly Tamang and Sherpa, it would have been of benefit if I had been conversant in the local languages. Language tends to be of mixed ethnic origin in the on-road areas, and most speak Nepali on a day-to-day basis. As a native speaker, sharing the same language enabled me to interact with communities and to ask follow-up questions when required in all three phases of my research. In my thesis, where appropriate, I have provided the original Nepali language both to allow future researchers to triangulate my data, and to review my own translation of these words and phrases.

3.4.10 Translations and transcriptions

Documents required for fieldwork were initially developed in English, including the preparation of questionnaires, consent forms, information sheets, guidelines for the PMEs and documentation for the demonstration model. The copies were reviewed and finalised in English, and then translated into the Nepali language and script. I undertook the first translations of the documents, which language experts at NSET then reviewed to ensure that I had captured the tone and tenor of the content before they were finally printed.

The fieldwork generated a sizeable number of recordings, transcriptions and then translations related to each step of the research: (a) from the household survey, particularly the open-ended questions and descriptions written in Nepali; (b) recordings of the approximately hour-long PMEs; and (c) the responses to and feedback from the demonstration sessions, captured through videos of the events that were held in the UBK. Challenges and barriers with regard to the transcriptions and translations were related to the volume of material and the difficulty at times of making precise transcriptions from often rapid and complex discussions. As the speed of discussion increased, so did the use of local languages. Capturing each participant's voice, identifying appropriate words for translation or finding words that represented the essence or meaning as accurately as possible was often challenging.

3.5 Conducting fieldwork

I conducted fieldwork in phases as the research progressed, managing the visits to the study area with my research studies at Durham University. In Table 3-2 I summarise the major tasks carried out during the implementation of the fieldwork.

Table 3-2. Phases of fieldwork and major tasks carried out during each phase

Fieldwork phase	Dates (month/year)	Major tasks carried out	Other notes
Scoping and preparatory work	2016–2017	Visited the Upper Bhote Koshi Valley, sometimes accompanied by supervisors/Durham University from the beginning of the research period and even before it commenced.	Enabled me to explore the area, establish links and internalise the situation in a post-disaster context.
Household survey	October–December 2018	Household questionnaire survey in four case study communities (two on-road: Hindi, Larcha; and two off-road: Listi and Marming). Foundation for next step of fieldwork, the participatory mapping exercises.	Local understandings and priorities and the position of landslide according to a householder's perception of the importance of such events in everyday life. (Details in Chapter 4)
Community survey	July–August 2019	Builds on the household survey carried out in four communities. The community survey considered one on-road community (Larcha) and one off-road community (Marming), and detailed participatory mapping exercises were carried out. Foundation for next step, the demonstrator and live demonstrations.	Community understandings of the geography of landslide hazards and risks using participatory mapping exercises to plot everyday landslides. (Details in Chapter 5)
Communicating information on landslide hazards and risks	August–September 2019	Development of model (the demonstrator), followed by testing and community demonstrations in the Upper Bhote Koshi Valley. (Hindi (on-road location) and Marming (off-road location)).	Integrated live demonstration system using a physical tool (landslide demonstrator). (Details in Chapter 6)

During the fieldwork, I detailed my activities and observations on a daily basis, keeping written records of the day's activities, including documenting emerging ideas and notes taken during the PMEs and live demonstrations. I held review meetings with my research assistants and recorded these in my diary. This process proved helpful in continuously enhancing the research on a day-to-day basis and identifying the issues that needed to be considered.

3.6 Data analysis

As this study adopted three research approaches, each generated quite different types and scales of data for analysis. I adopted different data analysis strategies for each objective when processing and representing the information obtained. Below, I provide a brief reflection on the analysis of the data and the knowledge gained from doing this. When analysing data, the possibility of 'misunderstandings are common when interviewing or discussing in diverse cultural contexts because of slight differences in meanings' (Valentine, 2005, p. 125). Despite my insider–outsider dilemma, described above, my interpretations are based on my interactions with the communities in which I collected data. The household survey data from 168 households were managed and analysed using SPSS (IBM, 2016). As detailed further in Chapter 4, the present study has not been of sufficient scale to derive what are always statistically representative samples, mainly when data could be subdivided or categorised for further analysis. This was in part a logistical challenge related to the number of households still resident in my field site after the 2015 GE, and partly a function of the breadth of respondents captured within this relatively small sample. Instead, I have focused on identifying trends and patterns in the categorical data and used primarily 'descriptive statistical methods' (Roterman-Konieczna, 2009). The descriptive method employs informative ways of illustrating and interpreting data gained from quantitative surveys in cases in which the collection of formal statistics may not have been possible or their analysis could be misleading.

Qualitative data contain a large amount of rich information; therefore, managing and analysing this was a lengthy process. Reflecting on the grounded theory approach (Saunders et al., 1997; Crang, 2007), the information collected during the PMEs was grouped into similar content, then categorised into broad groups of similar concepts that respondents used to explain the subject in question. Moreover, the approach offers a systematic and rigorous process of data analysis, achieving greater depth in the context of local phenomena such as landslide hazards and risks. Therefore, content analysis was the key method for identifying themes and emerging issues. When identifying themes in my qualitative data, the data were assigned different open codes according to an iteratively developed framework based on my experience from the PMEs, and then analysed accordingly (details are provided in Chapter 5). The local explanations from individuals and households and the collective community interpretations of landslide hazards and risks were extracted when interpreting the results. All transcribed and translated data were organised using NVivo (NVivo 11, 2012) for code assignation and categorisation according to the themes identified. In addition, completed mapping documents were visually analysed when making interpretations, and photographs were also visually evaluated.

Likewise, to evaluate the events in which the demonstrator was presented, I focused on analysing both the comments and conversations recorded during the demonstrations, and the written responses and feedback (explored in more detail in Chapter 6). The first part of the demonstrator process was documenting the process and the underlying concept, and the second was analysing the community response and feedback. Therefore, the analysis was based on the dialogue that took place during the demonstrations, visual recordings of the events, written feedback received in response to the demonstrations and direct observation of the participants as they watched what was happening.

3.7 Reflections on the research process

In the following sections, I describe some of my reflections on the research process, which I feel provide some valuable context for the research presented in this thesis. These relate to the post-2015 GE context of my field sites, the ethical considerations, dilemmas and limitations.

3.7.1 The research context: Nepal post-2015 GE

This research was carried out in a post-2015 GE context. The damage from the 2015 GE was perhaps most acutely felt in the UBK, with around 2,000 fatalities in this part of the affected area alone. This created a significant hazard context with highly active co- and post-seismic landslides and the associated shock waves having an impact on the communities in this valley. Several challenges related to the earthquake undoubtedly affected my research, which was carried out in a context of recovering from such an event. These ranged from minor issues from a logistical perspective to significant ethical issues associated with people's new priorities and pressing livelihood needs. Most people talked about the earthquake, their ongoing daily needs and issues related to out-migration and the international border closure with Tibet. The border trade was one of the major sources of income for the valley population before the earthquake. The valley is also the route of a major river that undercuts the hillsides and highway, leading to further ongoing disruption. New developments, such as rural roads and the development of hydroelectric power, have changed the valley significantly in recent years, both physically and socially.

My reconnaissance visit to the UBK was undertaken in 2017, two years after the 2015 GE. The valley was still in ruins, with most of the population absent, living in Kathmandu or elsewhere. The road was still closed, and in villages, most families had split up and were living in several different places as people of working age sought employment elsewhere. Women, children and older people tended to be left behind in their respective villages, whereas those able to earn a living were elsewhere in Nepal or often abroad. The subsistence agriculture that sustains many of these communities was a pressing concern. Importantly, I prioritised finding time to sit with respondents at all stages of my research. Inevitably, the situation I found was having an effect on the valley at the time of my research and also on people's perspectives with regard to their future prosperity and priorities.

Due to the extensive damage in the UBK after the 2015 GE, it was severely affected in the following monsoon seasons by further landslides, because loose materials were washed downslope in debris flows, leading to further intermittent disruption. The threat of rock falls from the ridges on the valley walls was real, such that walking during the rains was inadvisable, with work only possible in suitable weather conditions. Consequently, and for safety reasons, frequent disruptions to my fieldwork occurred, and there was a need to walk long distances along the highways in the absence of vehicular access. The rural trails were also heavily disturbed during the monsoon, requiring care and effort to organise each visit. As a result, there had to be several compromises in relation to rescheduling and postponing pre-planned meetings and, ultimately, the scale of what I have been able to achieve has been reduced.

There was no commercial accommodation in the valley during my fieldwork initially, despite there being many options before the 2015 GE. The Last Resort was the only place available, a commercial resort at Nayapul offering food and accommodation. Almost none of the householders could even afford a guest as a homestay, because most were either living in temporary shelters or their houses were still being (re)constructed; therefore, I stayed in Nayapul. The location is in the middle of all the fieldwork sites, so it was convenient, but I still had to walk long distances, often gaining over 1,500 m of height daily to reach my case study communities.

3.7.2 Ethical considerations and dilemmas

Conducting research in mountainous rural areas in developing countries such as Nepal can pose several ethical dilemmas because of the socio-economic situation. The ethical issues may relate to the power relations between the researcher and the communities (to be researched), knowledge generation, ownership of the research and exploitation issues (Banks and Scheyvens, 2014; Scheyvens, 2014). I adhered to a standard protocol on ethical considerations to protect and respect respondents' rights, dignity and privacy. I followed Sidaway's (1992) guideline, which advises that there are major three elements that need to be considered during research: (a) make no false promises; (b) be aware of any unintended consequences of your actions; and (c) share the results of your study. Moreover, Banks and Scheyvens (2014) propose a seven-point guideline following a bottom-up approach. The guideline summarises what researchers should do as follows: (a) address local needs; (b) foster mutual respect between community and researcher in relation to knowledge and tradition; (c) follow country and cultural protocols; (d) mutually benefit from the relationship; (e) act sensitively and respectfully; (f) ensure the value of research for the intended recipients; and (g) share findings, allowing dialogue and feedback (see Box 9.1 in Banks and Scheyvens, 2014).

Going back to my insider–outsider dilemma, I experienced community expectations in the discussions of the problems posed by local landslide hazards and risks. It was thought I would do the following: help communities to approach the *gaunpalika* officials; use my networks with foreigners to the communities' advantage; and relay communities' concerns to higher authorities and NGOs.

3.7.3 Exchanging findings with communities

The activities in each phase of my fieldwork build on the lessons learned from the former step(s). I followed the suggestion of Banks and Scheyvens (2014) in that I attempted to give something back to my participants, acknowledging their time contribution in sharing their experiences and knowledge. My intention here was to share the findings of my work in an accessible manner, promoting dialogue (Banks and Scheyvens, 2014, Box 9.1). In a practical sense, due to the timing of my fieldwork, it was not always possible to share all findings from the second phase of the fieldwork. I tried to share lessons learned at community meetings and during subsequent demonstrations as and where possible. On completing my thesis and in my work on DRR and landslides in Nepal in the future, I propose sharing my work with wider audiences. For example, at the time I am nearing completion of my thesis (summer 2021), my research on the demonstrator is being reproduced in an EU ECHO HIP-funded project, in which the modelling approach is being replicated in over 100 communities in two districts in Central Nepal, with a view to enhancing local decision-making in relation to landslide risk reduction. This work is a collaboration between Durham University, Northumbria University, NSET and the NGO People in Need.

3.7.4 Research limitations

When conducting fieldwork, on-site decisions had to be made to deal with a number of limitations, resulting in minor changes to my fieldwork strategy. These decisions related to site selection depending on the local and current circumstances, weather, accessibility of the field study area, available research assistants and having to organise meetings with communities in an evolving situation. I briefly discuss some of the compromises I had to make during fieldwork below.

The first decision involved a change of one case study community. Chaku is a local small market centre heavily damaged by the earthquake. Only a few households were living in Chaku and operating shops along the road during our first visits in 2016 and 2017. In addition, because Chaku was the site of a large new hydroelectric power project (the Madhya Bhote Koshi Hydroelectric Project), it was felt that the settlement was not a favourable location for completing the household survey. Hence, alternatively, I chose Hindi, the next village to the north of Chaku, and the site of the *guanpalika* offices.

In terms of in-depth research, my perspective here is as a geographer who is looking to explore the interaction between landslides and the people who live alongside them. I did not, therefore, seek to conduct a detailed ethnographic study. All interpretations have been made based on my own understandings gained from the communities I spent time with. I engaged with them over a relatively short period, although I made multiple visits. Thus, my findings and interpretations are based on community responses at the time of the survey, not on a more longitudinal perspective.

The household survey was conducted between October and December 2018. This is the season for the main festivals in Nepali communities: Dashain and Tihar. Communities engage in extended periods of celebrations, so this posed difficulties for me in implementing my fieldwork. The period after the festivals is also critical in the agricultural calendar for harvesting and planting.

My research assistants, Bishal, Chinay and Kedar, helped me in the first phases of my fieldwork, particularly in conducting the household survey. Bishal and Chenay were unable to accompany me after the first field visit, because Bishal had to return to university for classes, and Chinay had found a job in his village. Kedar was able to continue with me after Tihar until the end of the household survey. Despite being conscious of the need for continuity, I needed to find someone else to help with my fieldwork in the time I had available. I continued with Kedar for two extra weeks, because he knew the fieldwork areas, the trails and logistical arrangements. Most importantly, he knew the villagers. Therefore, the fieldwork timeline had to be rearranged according to these constraints. In the second phase of fieldwork in 2019, I appointed a new research assistant, Rajat, who had been an acquaintance. Rajat had no experience of working in hill and mountain areas, despite his previous wide experience as a fieldworker. I appointed him for three months, covering the whole fieldwork period. There was a gap between fieldwork stints, which meant a certain degree of backtracking, spending time with Rajat to explain the nature of the research and introduce the fieldwork process, but this was time well spent.

I found that the most rewarding research experience in the mountain environment was that the periods of fieldwork provided me with a greater appreciation of living very close to the sites that are being researched, adding to my trust in the research process (Leslie and Storey, 2003, cited in Oven, 2009). Despite this, I had limited opportunities for living directly in my respective communities. This was due to logistical arrangements and not wanting to be an additional burden to the householders in the difficult post-earthquake period of ongoing building reconstruction after they had experienced heavy losses in terms of both family members and property.

3.8 Summary

In this chapter, I explored the research context, fieldwork process and research strategies chosen, and the reasons for adopting this approach. I have summarised the methods adopted to achieve the goal of the research and explained the links between them. The research was carried out in a stepwise procedure: conducting household survey fieldwork; engaging in PMEs; and developing the landslide demonstrator. The details of each part of the research are fully explained in the chapters that follow.

Chapter 4

Local understandings of landslide hazards and risks

4.1 Introduction

An appreciation of local people's opinions on and insights into landslide hazards and risks is critical for effectively implementing DRR and management initiatives at the local scale (Oven, 2009; Oven and Rigg, 2015; Calvello et al., 2016; Gravina et al., 2017). In this part of my research, I explore local understandings of landslide hazards and risks through a household questionnaire survey, focusing on two on-road and two off-road locations in the UBK. This chapter discusses the findings, including the everyday hazards and risks faced by the householders who took part in the survey, before concentrating on local perceptions and understandings of landslide hazards and risks in the context of before and after the 2015 GE. It is intended that the detailed account of household knowledge will serve as a basis for future local LRM initiatives and inform decision-makers about perceived hazards and risks when local mitigation strategies are being developed. In addition, the findings informed the development of a physical landslide model, which was used as a tool to facilitate knowledge exchange with regard to landslide hazards and risks (see Chapter 6). In this chapter, I first describe the methods used for collection of the household survey data and then discuss the findings in the context of the wider academic literature.

4.1.1 Aim, research questions and objective

This chapter aims to understand how rural householders in the UBK perceive and understand landslide hazards, prioritise hazard and risk management, and predict the risk posed by landslides. Then, the study aims to explore how landslide risk can be better understood and managed in collaboration with communities.

In the context of the 2015 GE, losses due to landslide were widespread. Large cracks appeared across the landscape, increasing the susceptibility to landsliding in subsequent monsoons

(Kincey et al., 2020; Rosser et al., 2021). I was interested here in exploring how people made sense of and lived with this dynamic environment and the changing hazard and risk context, which was very different to that studied by Oven (2009) a decade before the earthquake. Specifically, my research asked the following questions:

- How do householders understand and respond to landslide hazards and associated risks following the 2015 GE?
- How do local understandings of landslide hazards and risk differ before and after the 2015 GE?

To address the research questions above, I seek to evaluate everyday landslide hazards and risks as perceived in terms of (a) location of landslides, (b) assessment of lived experience and current knowledge of landslides, (c) assessment of how householders see changing landslide hazards and risks, (d) anticipation of future landslide hazards and risks and (e) local management of landslide risk.

4.1.2 Local context

It is well documented that mountain communities in Nepal have a strong connection to their environment and an understanding of the physical landscape in which they live (Oven, 2009; Upadhya, 2009; Sudmeier-Rieux et al., 2012; Oven and Rigg, 2015). Such understandings include knowledge and awareness of landslide hazards and risks, including the causes and trigger factors, vulnerable locations and options for mitigation and management (Wachinger and Renn, 2010; Thapa and Adhikari, 2019). Multiple factors influence local understandings, including a householder's individual characteristics such as formal education, economic circumstances, age, gender, ethnicity, work experience and occupation (Gurung, 1989; Oven, 2009). In addition, a person's detailed knowledge of local landscapes may significantly affect household decision-making in relation to landslide risk reduction (Sullivan-Wiley and Gianotti, 2017). In line with these concepts, I explore how householders understand the lived experience of everyday landslide hazards and risks (Armaş, 2006; Ho et al., 2008; Manandhar et al., 2015; Calvello et al., 2016). Direct experience of landslides, and stories and information passed between generations about historic events, have previously been found to be important (Zhang et al., 2010; Dahal and Hagelman, 2011).

The household survey examined householder understandings of landslide hazards and risks and issues or phenomena near to where people live. The survey was undertaken in a post-2015 GE context in late 2018. At this time, over half of the valley population lived outside of their natal villages, and it was mainly the elderly, women and young children who remained. Family responsibilities such as childcare, caring for older family members and attending to social duties, fell to those left behind (Maharjan et al., 2015; Pandey, 2019) .

4.2 Methods and materials

In the section below, I explain the method and sampling design developed for the household survey, and the organisation and analysis of the results from the fieldwork. I used household questionnaire surveys to collect householders' responses and views, and they were applied in a semi-quantitative manner that enabled data analysis, as recommended based on previous comparable research (Ivankova et al., 2006; Palinkas, 2006; Creswell and Plano Clark, 2007; Johnson et al., 2007; Lund, 2012). In addition, I collated insights from conversations to supplement the information, again, as suggested in the literature. For example, Palinkas (2006) pointed out that a mixed-methods approach is appropriate in specific socio-economic settings where a high proportion of the population have low levels of education and income. In addition, conversations allowed me to explore insights, which complement and strengthen quantitative and qualitative data (Cieslik et al., 2019) to gain more depth (see Chapter 3). The household questionnaire survey was conducted with the four chosen communities in the UBK (see Figure 3-1 and Figure 3-7(a)), the choice and rationale for which has been discussed previously.

4.2.1 Questionnaire design and implementing a trial

The design of the questionnaire was based on comparable previous research on local (village) understandings of hazards and risks or risk perception at the household or community level (Gurung, 1989; Covey, 2001; Solana and Kilburn, 2003; Oven, 2009; Dahal and Hagelman, 2011; Calvello et al., 2016; Landeros-Mugica et al., 2016; Hernández-Moreno and Alcántara-Ayala, 2017). Summarised in Table 2-1, these studies were helpful when formulating questions and designing the household survey. Broadly, the household information was collected on 8 thematic topics, forming 37 core questions. These are presented in Appendix 6, and the themes are summarised below:

1. respondent profile;
2. household profile;
3. day-to-day problems;
4. knowledge about landslide hazards and risks;
5. direct experience of the impact of landslides at the household or community level;
6. uptake of measures for landslide risk reduction or any measures taken at the household or community level;
7. any household priorities with regard to landslide risk mitigation activities; and
8. potential implications of the study for local understandings of landslide DRR.

The first section of the questionnaire begins with the information about the respondent's household. This includes general details about the socio-demographics, including socio-economic circumstances, primary income sources, caste/ethnicity, education and home ownership. The second section, which is related to research question 1, aims to explore everyday household problems and natural hazards, specifically landslides. In the third section, the questionnaire explores the respondent's perception of future landslide hazards and risks. The fourth and fifth sections explore landslide hazards and risk reduction strategies and approaches. Finally, householders were asked how information on landslide hazards and risks could be more effectively shared between rural residents, local government and other stakeholders.

The survey included both open and closed questions. Some of the questions invited participants to rank or prioritise responses, whereas open-ended questions were aimed at exploring people's opinions and ideas in greater depth (Saunders et al., 1997; Crang, 2007). The questionnaire was initially designed in English, but for local implementation, questions were translated into Nepali, and time was spent considering how to translate the different concepts and ideas involved as accurately as possible . The Nepali translations were read by two DRR experts at NSET who have extensive experience of conducting research with rural communities. I revised the survey based on the feedback received in relation to both open-ended and closed questions. The review helped rectify inconsistencies, confirm feasibility and provided feedback on culturally sensitive issues (Scheyvens, 2014; Sanquini et al., 2016b). The household survey was piloted in an on-road community (Larcha) and an off-road community (Marming) to ensure the questions were simple, clear and unambiguous, and to calculate both the approximate time required with each household and the time needed to complete the entire survey (Moen and Ale, 1998; Oven, 2009; Acker et al., 2010; Bretton et al., 2018).

4.2.2 Selection of households for household survey

Household surveys were conducted in four communities in the UBK, as detailed in Chapter 3 (Figure 3-7). In preparation, these four communities were visited multiple times before the survey. The visits helped estimate and delineate the community areas to be covered, and assess the suitability of field sites based on their characteristics as follows:

1. multiple experiences of natural hazards, especially landslides;
2. size of settlements in terms of area and household number; and
3. on-road and off-road characteristics.

The survey was conducted between October and November 2018, shortly after the monsoon in the period leading up to the Dashai and Tihar festivals.

a) Enumerators and training

To carry out the survey, I worked with three enumerators, for whom I organised training sessions on the following: (a) background to my PhD study; (b) aims and objectives of the household survey; and (c) discussion of every question and its reasoning. To assist further, I also provided detailed guidelines giving an overview of the objectives of the study to accompany the questionnaire (see Appendix 7). Before conducting fieldwork, I introduced the enumerators to the communities, including key community members, to familiarise them with the overall survey area. The enumerators were trained in research ethics, in line with the approval received from the Department of Geography Ethics Committee at Durham University.

b) Selection of household head as the respondent

After finalising the strategy for household selection, the task of choosing an individual respondent for each household survey was given to the head of the household. Choosing the head as the primary respondent is common in rural Nepali societies, because the head undertakes most decision-making. It is also usual for the head to be the most economically active person, and the most senior (here, 67.3% of 168 survey responses were from the most senior member of the household, see Table 4-1). In the case of the non-availability of the head, the next most senior member of the family was selected, accounting for *c*.32.7% of responses. The higher number of female respondents observed here was attributed to the out-migration of men; the common practice in Tamang and Sherpa families is to regard the most senior member as the household head, and in this case many of them were women.

4.2.3 Summary of respondents' socio-economic circumstances

A total of 168 households were surveyed across the four communities (Table 4-1). The highest number of participants fell into the 45–59 age group (32.1%), followed by the 25–44 age group (29.2%) and then those over 60 (29.2%). Most of the respondents were >45 years old (61.3%), and slightly more of the respondents were male (54.2%). About 67.3% of respondents self-identified as household heads, whereas 32.7% of participants did not consider themselves household heads but were nonetheless playing a key role in household decision-making.

According to the results, most householders were of Sherpa and Tamang ethnicity (combined >61.3%), followed by Dalits (13.1%), Brahman–Chhetri (10.1%) and others (11.3%). Due to a range of social and historical reasons in relation to how different groups identify themselves, some householders did not describe their ethnic identity, most commonly those in Hindi. Culturally, some families consider themselves as belonging to the Sherpa clan, despite having roots in Tamang communities. However, despite their official identity or recorded ethnicity, the 'Sherpa and Tamang' category was used. The settlements of Larcha, Marming and Listi had largely homogenous populations with mostly Sherpa and Tamang families, whereas the roadside settlement of Hindi formed a more heterogeneous population of mixed ethnicities including Bhramin, Chhetri, Newar, Tamang and Sherpa families.

Table 4-1. Socio-demographic characteristics of the survey respondents

Respondent profile	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
Gender					
Female	28 (50.0%)	15 (55.6%)	14 (38.9%)	20 (40.8%)	77 (45.8%)
Male	28 (50.0%)	12 (44.4%)	22 (61.1%)	29 (59.2%)	91 (54.2%)
Age group					
Under 25	7 (12.5%)	2 (7.4%)	1 (2.8%)	6 (12.2%)	16 (9.5%)
25–44	18 (32.1%)	12 (44.4%)	4 (11.1%)	15 (30.6%)	49 (29.2%)
45–59	19 (33.9%)	5 (18.5%)	13 (36.1%)	17 (34.7%)	54 (32.1%)
60 and over	12 (21.4%)	8 (29.6%)	18 (50%)	11 (22.4%)	49 (29.2%)
Household head					
No	15 (26.8%)	11 (40.7%)	7 (19.4%)	22 (44.9%)	53 (32.7%)
Yes	41 (73.2%)	16 (59.3%)	29 (80.6%)	27 (55.1%)	113 (67.3%)

(Source: Field survey, 2018).

Over 83.9% of householders surveyed lived in a house they owned. This figure is slightly lower than the data from the *gaunpalika* profile, in which about 92.0% of householders own their own home, 5.5% live in rented housing, 1.8% live with other families and 0.3% live on public or government land (Bhotekoshi Gaunpalika, 2019). The remaining families live in either rented (2.4%) or shared accommodation (7.1%) with other families, including in their own house built on rented or public land, which does not constitute land ownership. It was common for survey participants to be in rented accommodation at the roadside but also to own a house in their natal village higher in the valley.

Table 4-2. Socio-economic characteristics of survey respondents

Socio-economic characteristics	On-road		Off-road		
	Hindi	Larcha	Listi	Marming	Total
Households (*n*)	**56 (100%)**	**27 (100%)**	**36 (100%)**	**49 (100%)**	**168 (100%)**
Ethnic Category					
Brahman	1 (1.8%)	-	1 (2.8%)	-	2 (1.2%)
Chhetri	9 (16.1%)	2 (7.4%)	3 (8.3%)	1 (2%)	15 (8.9%)
Magar-Gurung	1 (1.8%)	1 (3.7%)	-	-	2 (1.2%)
Sherpa-Tamang	13 (23.2%)	24 (88.9%)	27 (75%)	39 (79.6%)	103 (61.3%)
Dalits	17 (30.4%)	-	4 (11.1%)	1 (2%)	22 (13.1%)
Others (specify)	10 (17.9%)	-	1 (2.8%)	8 (16.3%)	19 (11.3%)
Not stated	5 (8.9%)	-	-	-	5 (3%)
Education level					
Non-literate	26 (46.4%)	19 (70.4%)	25 (44.6%)	3 (6.1%)	73 (43.5%)
Simple-literate	20 (35.7%)	5 (18.5%)	8 (14.3%)	45 (91.8%)	78 (46.4%)
Primary level	-	-	2 (3.6%)	-	2 (1.2%)
Secondary level	6 (10.7%)	2 (7.4%)	-	-	8 (4.8%)
Higher secondary level	1 (1.8%)	1 (3.7%)	-	1 (2%)	3 (1.8%)
Not stated	3 (5.4%)	-	1 (1.8%)	-	4 (2.4%)
Occupation					
Not stated	8 (14.3%)	-	3 (5.4%)	2 (4.1%)	13 (7.7%)
Agriculture/farming	28 (50%)	21 (77.8%)	29 (51.8%)	40 (81.6%)	118 (70.2%)
Formal employment	1 (1.8%)	-	-	1 (2%)	2 (1.2%)
Daily wage labour	3 (5.4%)	-	1 (1.8%)	-	4 (2.4%)
Own business	7 (12.5%)	1 (3.7%)	1 (1.8%)	1 (2%)	10 (6%)
Unemployed	-	1 (3.7%)	-	-	1 (0.6%)
Student	1 (1.8%)	1 (3.7%)	-	1 (2%)	3 (1.8%)
Others (specify)	8 (14.3%)	3 (11.1%)	2 (3.6%)	4 (8.2%)	17 (10.1%)
Home Ownership					
Owned	45 (80.4%)	24 (88.9%)	28 (50%)	44 (89.8%)	141 (83.9%)
Rented	1 (1.8%)	3 (11.1%)	-	-	4 (2.4%)
Others-specific	4 (7.1%)	-	4 (7.1%)	4 (8.2%)	12 (7.1%)
Missing/ not stated	6 (10.7%)	-	4 (7.1%)	1 (2%)	11 (6.5%)
Main source of income					
Formal employment	3 (5.4%)	-	-	1 (2%)	4 (2.4%)
Casual employment	1 (1.8%)	-	-	1 (2%)	2 (1.2%)
Casual labour	1 (1.8%)	1 (3.7%)	-	1 (2%)	3 (1.8%)
Agriculture/farming	21 (37.5%)	18 (66.7%)	28 (50%)	32 (65.3%)	99 (58.9%)
Social welfare/pension	1 (1.8%)	-	-	-	1 (0.6%)
Family business	3 (5.4%)	-	-	-	3 (1.8%)

(Source: Field Survey, 2018).

In terms of household economy, most householders reported agriculture or farm activities (58.9%) to be their main source of income (Table 4-2). Some differences in sources of family income between on-road and off-road locations have been documented. For a householder living off-road, the primary economic activity was subsistence farming. On-road householders have more diversity in income, including running local grocery shops, teashops and other small-scale businesses. Additional household income included daily wage labour, seasonal employment on local projects, housing reconstruction (after the 2015 GE), and daily sand collection from the riverside. Only a small number of households receive income from formal employment (2.4%), and this includes members who are teachers, have government jobs or who have permanent positions either within the *gaunpalika*, or beyond (Table 4-2). In terms of educational background, 43.5% of respondents were non-literate, whereas 46.4% reported having basic literacy according to the 2014 Central Bureau of Statistics definition of having *the ability to read and write a simple sentence*. Of the respondents, 6.6% reported having completed secondary/higher secondary education (those of *c*.18 years of age, equal to 12 years of education).

4.3 Findings

In the following sections, I discuss the key findings from the household survey and explore local understandings based on the survey data, examining the following issues:

1. Local understandings of everyday hazards and risks, and the significance of landslides;
2. Lived experience and knowledge of landslides;
3. Changing understandings of landslide risk;
4. Anticipating future landslide risk; and
5. Managing landslide risk.

4.3.1 Everyday hazard and risk, and the significance of landslides

At the beginning of the survey, respondents were asked to report householders' everyday concerns. Open-ended answers (see Q1 and Q2 in Appendix 6) included anything from natural hazards to day-to-day needs such as access to clean water. The summary of the overall results shows that people are worried about everyday problems, such as a source of clean drinking water, access to roads, landslides, wild animal attacks on their crops and the availability and accessibility of health facilities. Figure 4-1 shows the Wordle of keywords, scaled according to the relative frequency of the problems reported by householders.

Figure 4-1. Wordle of everyday worries of households, in response to Question 2 of the household survey.

As shown in Table 4-3, most householders identified the lack of reliable drinking water in their *toles* (94.6%). Here, the *tole* represents a small neighbourhood of 8–20 houses in general, because the communities are mainly characterised by dispersed slope settlements. In addition, lack of access to the main road (95.2%), attacks by wild animals, particularly eating and trampling crops before harvest (91.7%,), lack of access to health facilities, especially if a family member falls ill (92.9%,), problems with electricity supply (92.3%) and poor local road conditions, especially in the monsoon (91.7%), were the most frequently reported everyday problems. Participants also expressed concerns about landslides blocking roads and walking trails used on their daily commute to farmland, the market centre or school.

Table 4-3. Summary of major daily worries or everyday problems as reported by householders

Major daily worries	Response (*n*/%) *n*=168	No response (*n*/%)
Drinking water	159 (94.6%)	9 (5.4%)
Road access	160 (95.2%)	8 (4.8%)
Wild animals	154 (91.7%)	14 (8.3%)
Access to health facilities	156 (92.9%)	12 (7.1%)
Electricity	155 (92.3%)	13 (7.7%)
Local roads	154 (91.7%)	14 (8.3%)

(Source: Field survey, 2018).

Wild animal attacks that damaged overall household crop production were commonly reported. The consequences created new problems, placing an additional burden on livelihoods and raising wider tensions in relation to local conservation projects (e.g. National Parks). Householders said this problem had become more severe with the increasing number of wild animals introduced into the area as part of the Gaurishankar Conservation Plan launched in 2010 that covers 22 former VDCs in the Sindhupalchok District, including the UBK.

Respondents were asked to identify their three most challenging household problems. Based on their ranking, drinking water was the main concern (25.6% out of 164 responses). The second priority concern was access to roads (19.0% out of 116 responses) and the third was limited availability of health facilities (17.8% out of 73 responses) (see Table 4-4). The other main priorities identified included availability of drinking water (25.6 %), landslides (12.2%), road access (8.5%), water supply (7.3%) and attacks by wild animals (7.3%). Notably, landsliding always featured as a high-priority concern.

Table 4-4. Priority concerns as identified by survey participants.

SN	First	# households (%)	Second	# households (%)	Third	# households (%)
1	Drinking water	42 (25.61%)	Road (access)	22 (19%)	Health post	13 (17.8%)
2	Landslides	20 (12.2%)	Landslides	20 (17.2%)	Road (access)	7 (9.6%)
3	Road (access)	14 (8.54%)	Drinking water	15 (12.9%)	Electricity	6 (8.2%)
4	Water (rain)	12 (7.32%)	Wild animals	7 (6%)	Landslides	5 (6.8%)
5	Wild animals	12 (7.32%)	Electricity	5 (4.3%)	Drinking water	4 (5.5%)
6	Local road	11 (6.71%)	Local road	4 (3.4%)	Local road	4 (5.5%)
7	River cutting	7 (4.27%)	Water (rain)	3 (2.6%)	Water	4 (5.5%)
8	Flood	3 (1.83%)	Health-post	3 (2.6%)	Low productivity	3 (4.1%)

SN: serial number, (Source: Field survey, 2018).

There was also a qualitative difference between the everyday concerns of participants in the on-road and off-road communities (Table 4-5). Participants in Hindi and Larcha (on-road locations) were more concerned about the quality of available drinking water (94.6%) and the supply being interrupted during the monsoon. These disruptions are mainly caused by landslides located in between the water source and the village. In the Marming and Listi off-road communities, villagers were concerned about the availability of a piped water supply, because the community has no local reliable supply. The off-road location respondents cited the importance of agriculture for meeting their livelihood needs. In Listi, respondents were concerned about the growing impact of wild animals, especially over the last four to five years. However, in Marming, respondents were less concerned about attacks by wild animals but more so about the effect of small-scale landslides putting their houses and farmland at risk. The extensive distribution of minor landslides over the area around the village was also an additional concern for the householders in Marming. Because the Marming community is close to the Chaku Khola, concerns were voiced about the sediment carried and the erosion, particularly where the river flows along the bottom of the village, potentially undercutting the slope. In relation to this, debris deposition during the monsoon was considered the most severe concern.

Table 4-5. The everyday concerns of survey participants in the four case study villages

Householders' daily worries	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
Drinking water	47 (83.9%)	27 (100%)	36 (100%)	49 (100%)	159 (94.6%)
Main road	48 (85.7%)	27 (100%)	36 (100%)	49 (100%)	160 (95.2%)
Wild animals	42 (75.0%)	27 (100%)	36 (100%)	49 (100%)	154 (91.7%)
Access to health facilities	44 (78.6%)	27 (100%)	36 (100%)	49 (100%)	156 (92.9%)
Electricity	43 (76.8%)	27 (100%)	36 (100%)	49 (100%)	155 (92.3%)
Local roads	42 (75.0%)	27 (100%)	36 (100%)	49 (100%)	154 (91.7%)

(Source: Field survey, 2018).

As shown in Table 4-5, the most frequent and disruptive issues, such as access to drinking water, received the greatest attention from householders. The consequences of landsliding remained the second priority, whether these had a direct or indirect effect on householders' lives and assets.

4.3.2 The lived experience of landslide hazard

In Section 4.3.1, I presented an overview of the socio-demographic characteristics of the survey respondents and the everyday concerns they faced. A householder's lived experience of a hazard can be explained as one of the key factors shaping his/her risk perception (Zhang et al., 2010; Jianqiang et al., 2016; Klonner et al., 2018). For instance, respondents repeatedly reported having very little choice with regard to where they live, despite their concerns about possible future landslides in some locations. The common identification of landslide hazards in the survey highlights that they present a significant perceived threat to people's lives and livelihoods. Participants reported damage to and destruction of property, concerns about the increasing number of landslides, cracks appearing across their land, disruption to the water supply and roads being frequently blocked, all associated with mass movements. On the other hand, the lived experience from less frequent or slow-onset landslides (e.g. slow-moving landslides, creeping or occasional rock falls), might have been overlooked and may not be considered as a day-to-day risk in the survey results.

The intention of the question 'What are the main hazards and risks that you face in the village?' (Q2, Appendix 6) was to explore the degree to which respondents identified landslides as the most frequent hazard event affecting householders in the village (Table 4-6). Out of 168 householders, 165 (98.2%) reported landslides as the most frequent hazard in their village. Other reported recurrent hazards included earthquakes (91.7%), strong winds (91.7%), heavy rainfall (91.1%) and wild animal attacks on crops (91.1%).

Table 4-6. The main natural hazards experienced in the village

Natural hazards	On-road		Off-road		Total
	Hindi	Larcha	Listi	Marming	
Households (n)	56	27	36	49	168
Landslides	53 (94.6%)	27 (100%)	36 (100%)	49 (100%)	165 (98.2%)
Earthquakes	43 (76.8%)	27 (100%)	36 (100%)	48 (98.0%)	154 (91.7%)
Strong winds	43 (76.8%)	27 (100%)	36 (100%)	48 (98.0%)	154 (91.7%)
Heavy rainfall	42 (75.0%)	27 (100%)	36 (100%)	48 (98.0%)	153 (91.1%)
Wild animals	42 (75.0%)	27 (100%)	36 (100%)	48 (98.0%)	153 (91.1%)
Others	7 (12.5%)	-	-	5 (10.2%)	12 (7.1%)

(Source: Field survey, 2018).

In response to the question 'Have you experienced any landslides in the village?' (Q3, Appendix 6), 87.5% of respondents reported having experienced at least one landslide in the past, whereas 6.5% of respondents reported no direct experience (Table 4-7). This included any type of experience affecting their households, for example, injury, damage to the house, loss of farmland and roadblocks disrupting access to and from the village. Larcha and Marming reported the highest number of households with direct experience of landslides (89.8%), followed by Hindi (83.9%) and Listi (83.3%). However, although an off-road/on-road comparison can be made, the results remain very local and are influenced by the households' site-specific characteristics.

Table 4-7. Participants' experiences of landslides in the case study villages

Have you experienced any landslides in the village?	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (n)	56	27	36	49	168
Yes (experienced)	47 (83.9%)	26 (96.3%)	30 (83.3%)	44 (89.8%)	147 (87.5%)
No (not experienced)	4 (7.1%)	1 (3.7%)	5 (13.9%)	1 (2%)	11 (6.5%)
No answer	5 (8.9%)	-	1 (2.8%)	4 (8.2%)	10 (6.0%)

(Source: Field survey, 2018).

The implications of lived experience for adopting landslide hazard and risk mitigation measures at the household level depend on its degree (Wachinger et al., 2013). Direct experience, as opposed to hearing about others' experiences, is likely to have the greatest impact on perceived risk. For instance, the UBK has experienced high landslide hazard and risk levels following the 2015 GE (Kincey et al., 2020). Therefore, it is not surprising that all householders were concerned about the threat of landslides in the future based on their own direct previous experience, and the experience of other communities in the valley (indirect). Moreover, such exposure may substantially affect householders' everyday decision-making, for example, where to rebuild their house, which way to walk or when to plan to visit relatives.

4.3.3 Householder understandings of the geography of landslide hazards and risks

The survey findings suggest that householders have an in-depth knowledge of the location of landslides around them (Table 4-8) when initially asked where landslides have occurred in their village. However, participants often responded that 'landslides are everywhere, have a look!' (*jata-tatai pahirai-pahiro chha, hernus na!*), indicating a pervasive landslide distribution in the area, but did not specifically define particular locations in the first instance. Further conversations and responses led to householders identifying more specific locations, indicating a more detailed knowledge of the landslide source and area affected. The responses, grouped by location (Table 4-8), give a first impression that communities identify broad areas relative to their location as known sources of landslides, and they include statements such as 'the top of or above the village', 'the bottom part or below the village' and at 'roadside locations'.

Table 4-8. List of quotations from householders about the location of landslides

Communities	Locations and descriptions
Hindi (on-road)	Everywhere after the earthquake; Several new water springs appeared and old [springs] disappeared; Landslides originated in the middle of village; Across [from] the house [my building]; Just below the road – [i.e. local roads in the village]; Undercutting by the river [Bhote Koshi river]; No problem of the landslide in Chaku; Some [landslides] from mid-village, some [come, originate from] the upper part of the village [originate from the top of the hill]; Yes, originate around the village, and also are above the village.
Larcha (on-road)	The landslide started [originated] from the steep slope (*bhir* भीर cliff) reached to the daily walking local, like highway side; Cracks, the new source of water appeared temporarily and older sources dried; Pulled by the river [undercutting from the Bhote Koshi river]; Middle of the village and top of the village has many landslides; No problem of landslides like in Chaku.

Communities	Locations and descriptions
Listi (off-road)	At the bottom of the village; At the top of the village; Every river [local small stream] carry excessive sand mixed water (*khahare खहरे*) in monsoon, enter to the village (*khahare खहरे गाउँ पस्छ*); Pulling from the bottom of the village (*gaaun ko puchar bata taneko chha गाउँको पुछारबाट तानेको छ*); Landslide at the bottom of the village.
Marming (off-road)	Bottom of the village, at the edge of farmland (dry, unirrigated farmland *baari बारी*); Another side of the village; Half of the village in threat due to the landslide [meaning all the village is threatened]; Near, below the [*baari*], and below my house; Landslide started from the *bhir* (*भीर* grassy cliff) to be reached up to [local] road; At the bottom of the village in danger, might burst (*ekkasi bhatikine एक्कासी जोडले भत्किने*) instantaneously collapse at any time; From bottom of the village (*gaaun ko pucharbata गाउँको पुछारबाट*) near to the *baari* farmland (*kheti baari खेतीबारी,जमीन*); Cracks are visible in many places, the new springs, older sources also dried; Dozer, causes after road construction; landslides are caused by excessive rain in our village, deforestation, fewer plants in the village, pulling land from the bottom of the village; from the top of the village; Just below my house [three repeats] and below the *baari*; At [from] the edge of the river (*खोलाछेउ वाट*, 2), very close to river cutting and local road construction sites; The opposite [Narayanthan] side of the village (*paharaa पहरा* cliff), ghatta (*पानी घट्ट,* watermill) is still pulling by *pahiro*.

(Source: Field survey, 2018).

Participants were asked to identify the most at-risk areas in the UBK. The most repeatedly identified places were Kodari, Tatopani, Chhyadi, Daklang and Hindi (village) (Table 4-9). In addition, the Jure landslide (some 20 km south of the *gaunpalika* office) was also mentioned because it blocked the valley in 2014. Table 4-9 illustrates that householders have an in-depth knowledge of landslides in the valley.

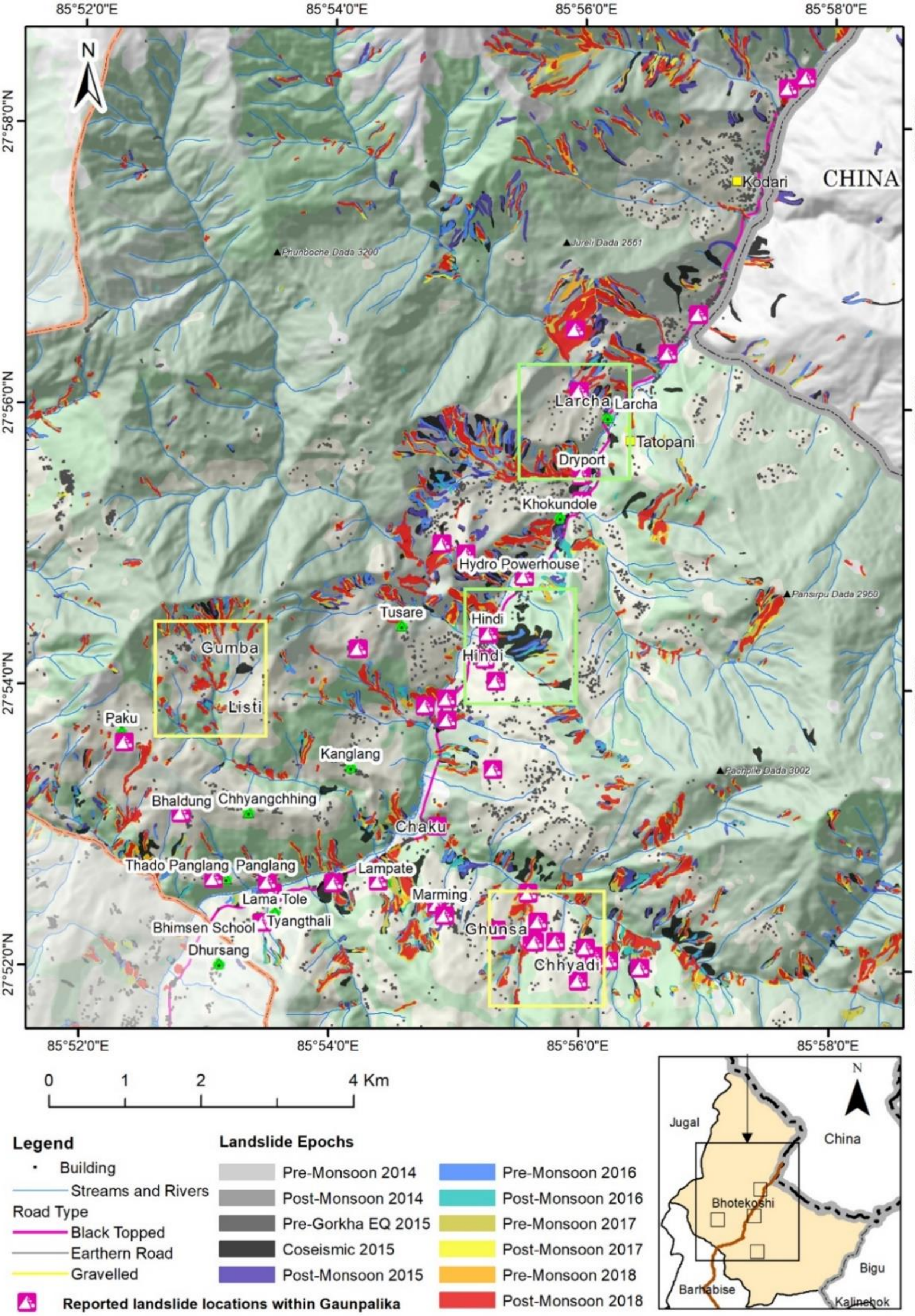
Table 4-9. The most problematic landslide locations known to householders in the *gaunpalika*, the Upper Bhote Koshi Valley and the country

Particular location or landslide	Named villages	General areas
(a) In the *gaunpalika*		
Daklang 4 Kilo (2); 8 kilo (1); 9 kilo (1); Aale-gaun (1); Bahrabise (1); Bhirkuna (1); Chhyadi (11); Daklang (3); Dharapani (2); Dugna (4); Fumachhe (4); Ghunsa (2); Gondojet (1); Hindi (3); Jhyalekuna (2); Kalapan (1); Karmasingh	Marming (4); Mararmang (1); Ghunsa (7); Gumba (2); Hindi (6); Tatopani (2); Around village (3);	Landslide comes from all four directions (1); School dada (1); Around village (1); This area (1); Bottom of the village (1); Don’t know (1); Everywhere (1); May be equal everywhere

Particular location or landslide	Named villages	General areas
(2); Kobokuna (1); Kolgaun (2); Lambate (2); Larcha (5); Lichipu (1); Liping (2); Luksing (3); Manthang (1); Rangjangkuna (1); Sangmani (6); Saptabal (2); Sarawang (5); Tatopani (3); Bangbachhe (1); Bhote Koshi bridge area (1); Chaku (2); Dathali (1); Ghoran (1); Kodari (2); Maratma (1); Pau-gumba (1); Peri-gaun (1); Singari-dada (1). Total response = (138)	Duguna (1); School dada (1); Listi (1); Larcha (3). = 31	(1); Near to hydropower (1); No landslide in my village (1); Other villages mainly (1); Other side of river (2); This area (2); This village (1); Roadside area (1); Ward 4 (2); (former) Ward 8 and 9. = 19
(b) In the UBK		
Chhyadi (1); Dharapani (2); Duguna (3); Gati (1); Jambu (1); Jure (5); Riverside (1); Sarbang (1); 10 kilo (1); Bhirkuna (1); Bhotekoshi (1); Chaku (4); Gumba (1); Jhyale-bhir (1); Khorang (1); Liwang (1); Luksing (1); Marming (2); Sabang area (1); Sangmani (2); Sirise (1). Total response = (56)	This village (1); Ramche-gaun (1); Tatopani (4); Bahrabise area (1); Kodari (2); Listi (1). = 10	Not here but in Duguna (1); Other side of Chaku (1); Our village (1); Palika side – Hindi (1); This area (1); This village (1); This area (3); Roadside (2). = 11
(c) In the country		
Duguna (1); Bhirkuna jungle (1); Bhote Koshi (7); Gumba (1); Our village only (1); Tatopani (2); This area (2). Total response = (15). Note: Number in parenthesis are frequency of response. 'Kilo' refers name of place, not the unit; multiple names were possible.	Jure (2)	All over the country (1); Dolkha (1); Gorkha (1); Riverbank area (1); All hill area (2); Rasuwa (1); Sindhupalchok (4); Everywhere same (1); Bhote Koshi valley (1); Don't know (5). = 18

(Source: Field survey, 2018).

From Tables 4-8 and 4-9, the variation in responses shows the most problematic areas across the valley (see Figure 4-2). For instance, in Marming, the community is worried about the Chaku Khola undercutting the slope and the resulting instability affecting the village. Apparently, the situation is worsened by frequent blasts from the construction of the hydroelectric power plant, generating new threats (*dar* (fear)) in already weak locations.



(reported landslide locations plotted according to Table 4-8).

Figure 4-2. Most problematic landslides named by householders in the Bhote Koshi *Gaunpalika*.

Respondents also compared the landslide risk in their village with that of neighbouring villages, deeming it to be either smaller or greater (Q10, Appendix 6). The highest proportion of respondents considered their village under a threat of landslides that was ‘greater than other villages’ (44.0 %) and believed their village to have relatively more significant problems than others in the locality (Table 4-10). Another 27.4% of respondents considered their village to have almost the same extent of landslide problems as neighbouring areas. Of the respondents, 14.9% considered their village to have fewer landslide problems, and around 6.0% considered other places to have bigger problems (see Table 4-10). Typically, therefore was a view that ‘my problems are greater than those experienced by others’, seen in 45.2% of responses. From this point of view (shown in Table 4-10), there is no clear distinction between on- and off-road locations, beyond a higher percentage of people viewing their village as having more problems than others. However, householders in on-road locations typically described a greater degree of interaction along the highway and valley bottom associated with everyday living, and were more familiar with the highway and the landslide conditions around it. In contrast, off-road households were more aware of landslide events around their villages that were associated with everyday interactions in relation to farming, and fodder collection. A more detailed community perspective on these interactions is explored in Chapter 5.

Table 4-10. Householders’ perceived comparison of landslide hazards and risks between their own and surrounding villages

Comparison with neighbouring villages	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
Smaller than other villages	7 (12.5%)	4 (14.8%)	10 (27.8%)	4 (8.2%)	25 (14.9%)
Same as other villages	17 (30.4%)	9 (33.3%)	7 (19.4%)	13 (26.5%)	46 (27.4%)
Greater than other villages	27 (48.2%)	13 (48.1%)	14 (38.9%)	20 (40.8%)	74 (44.0%)
Much greater than other villages	-	-	1 (2.8%)	1 (2.0%)	2 (1.2%)
Other places	-	1 (3.7%)	3 (8.3%)	6 (12.2%)	10 (6.0%)
No answer/no idea	5 (8.9%)	-	1 (2.8%)	5 (10.2%)	11 (6.5%)

(Source: Field survey, 2018).

In Table 4-10, respondents provided everyday observations of landslides. These accounts described the impact of landslides on their daily lives, for example, the effect they had on commuting routes to farmland or school for children, or travelling to the local marketplace. Villagers from off-road locations also visited the highway to buy household goods and to visit relatives and health facilities. These journeys were described with reference to specific landslide locations, and the potential consequences for their house and farmlands. For example, respondents from Marming and Listi (off-road) usually mentioned the source of the landslides in a clear and precise manner. Continuing the same question about the source of landslides, villagers from both locations suggested that landslide problems are quite significant for valley bottom settlements and for people living in on-road locations. Similarly, they were less aware of the exact location of landslides originating from hilltops or the ridges above their own settlements, higher in the mountains. However, householders living in off-road settlements were commonly aware of such locations and provided more accurate details for landslides close to their houses. For example, in Marming and Listi, villagers expressed their concerns about both valley and hilltop locations and the potential impact of landslides in both areas on their farmland (*khetbari*) and key walking trails. As such, the answers given by respondents very much reflected everyday encounters and apparently very localised understandings associated with the geography of their own daily interactions, activities and experiences.

4.3.4 Recognising landslide types

Recognising landslide type is essential in assessing the hazards and risks they pose, and how to manage them. The term 'landslide' involves various processes resulting in the downward and outward movement of material (Varnes, 1978; Highland, 2004). This movement includes falling, toppling, sliding, spreading or flowing of rock and soil, with different levels of water content (Varnes, 1978; Cruden and Varnes, 1996; Milledge et al., 2018, 2019). Recognising such landslide types can help householders to distinguish and identifying a landslide's (likely) evolving nature and behaviour, and help them to choose appropriate remedial measures (Varnes, 1978). When asked which types of landslides householders observed locally, the responses included (Table 4-11) rock falls (57.7%), earth flows (>42.3%), creeping failures (11.3%) and land subsidence (*jamin bhasine*), due to the high level of rainfall in the monsoon (8.9%). The same Table (4.11) further highlights rock falls as the most frequently mentioned type of landslide, especially in Larcha (81.5%), followed by Marming (65.3%) and then Listi (47.2%).

It was understood from conversations that due to the local geological materials, landslides in this area are dominated by rocks and soil, primarily taking the form of rock falls and debris flows. Notably, these were very common in the earthquake. On the other hand, slow-moving landslides, for example, observations of 'creeping' and/or 'land subsidence' were reported less often, despite there being several long-term landslides of this type in the valley. The findings, based on villagers' observations, suggest that rock falls were the main landslide type experienced in Larcha and Marming, whereas earth flows were common across all four communities.

Table 4-11. Percentage distribution of major landslide types reported by householders as per their experiences

Location	Hindi	Larcha	Listi	Marming	Total
Households (*n*)	56	27	36	49	168
Rock falls	26 (46.4%)	22 (81.5%)	17 (47.2%)	32 (65.3%)	97 (57.7%)
Earth flows	23 (41.1%)	12 (44.4%)	6 (16.7%)	30 (61.2%)	71 (42.3%)
Creeping (very slow)	8 (14.3%)	2 (7.4%)	1 (2.8%)	8 (16.3%)	19 (11.3%)
Land subsidence	5 (8.9%)	2 (7.4%)	4 (11.1%)	4 (8.2%)	15 (8.9%)

(Source: Field survey, 2018).

Note: If yes, what kind/type of landslides have you experienced? Original response: rock falls (*dhunga khasne* ढुँगाखस्ने); earth flows (*jamin bagne* जमीनबग्ने); creeping (slow and long-term movement of land, *jamin bistarai bagne* जमीन विस्तारै बग्ने); land subsidence (*jamin bhasine* जमीन भासिने). Participants can have multiple answers.

Participants also identified landslide types in ways that did not readily match scientific typologies. These community definitions reflected how locals use different words denoting such events, for example, the common term *baadhi-pahiro* (flood landslide). This term also describes the speed as well as the materials carried. For instance, in Marming, householders referred to a *pahiro* (landslide) as meaning 'all materials'. Essentially, this was a debris flow (mixed materials, including soil, smaller boulders and vegetation). Such (flood) materials are described as *khahare badheko* (coarse sandy material). Moreover, in terms of their origin, Marming villagers used the term 'landslide' for events that originate from the upper part of the village and appear as *baadhi* (flood) with large and very fast-moving debris because of the steep slopes and high water content involved. Hence, the local meaning of landslides depends on local topography, the origin of the material and the water content, which might not necessarily be distinguishable in scientific terminology.

Interestingly, respondents did not differentiate by landslide type during everyday conversations, but commonly mentioned landslides as fast-moving events in the very first instance, and then refined this in follow-up conversations to describe the landslide as slow moving, involving rock falls or creeping as observed around the village. Moreover, multiple descriptions of varous characteristics were offered in response to questioning: speed (fast/slow, creeping, subsidence); material type (debris, or *khahare*); the place of origin, which was commonly directly associated with channels (*kholale kateko*, *nadi-katan*); indicators of landslides (small cracks) alongside changes to the local landscape again via cracks (*chira pareko*, *dhaja phateko*); undercutting at the valley bottom (*phedibata kateko*, *nadi-katan*); and gullying (*kholso pareko*). These informal definitions of landslides can overlap or present gaps in types if compared with more formal definitions.

4.3.5 Awareness of landslide trigger factors

As far as hillslope failure in the Nepal Himalaya is concerned, heavy rainfall is the most common trigger factor for landslides (Adhikari and Koshimizu, 2005). The 2015 GE triggered many landslides, notably in the earthquake-affected districts, including the UBK, and left slopes more susceptible to future rainstorms (Williams et al., 2018; Kincey et al., 2020; Tian et al., 2020; Rosser et al., 2021). In addition, human activities such as road construction, deforestation, housing construction and other development works (Highland, 2004; Highland and Bobrowsky, 2008) are considered to be further causes of landslides. In such a context, this study sought to understand householders' awareness of causes and trigger factors, both now and in the future. A multiple choice question was asked: What are the main causes or trigger factors for landslides in the village? (Q7, Appendix 6). Options included 'heavy rainfall', 'deforestation', 'road – highway or rural road', 'earthquakes' and 'other'. In response, the highest proportion of respondents (53.0%), suggested that 'heavy rainfall' is the primary cause of landslides in the valley (Table 4-12), followed by local (rural) road construction (11.3% respondents), earthquakes (6.0%) and deforestation (2.2%). An additional 32.1% of respondents suggested that substandard development works, such as improper road construction, poor drainage of local roads, abandonment of land due to out-migration, inappropriate farming practices or the merging of monsoon runoff channels due to inadequate drainage of farmland ('other' in Table 4-12), all led to landslides.

Table 4-12. Perceived causes and trigger factors of landslides in the case study communities

Location	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	*n* (%)
Heavy rainfall	37 (66.1%)	19 (33.9%)	16 (28.6%)	17 (30.4%)	89 (53.0%)
Deforestation	2 (3.6%)	2 (3.6%)	-	-	4 (2.2%)
Roads (highway/rural)	13 (23.2%)	1 (1.8%)	2 (3.6%)	3 (5.4%)	19 (11.3%)
Earthquakes	5 (8.9%)	1 (1.8%)	2 (3.6%)	2 (3.6%)	10 (6.0%)
Others	16 (28.6%)	9 (16.1%)	5 (8.9%)	24 (42.9%)	54 (32.1%)

(Source: Field survey, 2018).

Note: The total number or percentage for location could exceed 100% because the respondents could choose more than one cause of landslide.

The results also showed (Table 4-12) that in Hindi, around two-thirds (66.1%) of respondents believed heavy rainfall to be the main trigger factor for landslides, followed by 23.2% of respondents who viewed repairs to the the highway or rural road construction as a likely cause and 8.9% who identified earthquakes as the trigger factor for landslides in the valley. In Marming, 30.4% of respondents considered heavy rainfall to be the cause of landslides, whereas 42.9% of respondents used the 'other' category, which included development projects, local road construction, weakened slopes, etc. The results reflect the dominant cause of landsliding in this area, but also the wide range of factors that contribute to it.

Householders' knowledge about the seasonality of landslide trigger factors was explored by asking the following question: What time of year do these landslides occur? (Q8, Appendix 6). Most respondents reported landslides starting in *Asar* (early monsoon, June–July, 52.8%), followed by *Shravan* (July–August or mid-monsoon, 32.4%). Only 10.2% of participants reported landslides occurring in *Jestha* (early June, just before the onset of the monsoon) and 3.7% in *Bhadra* (towards the end of the monsoon August–September) (Figure 4-3). Despite being asked an open-ended question, no householders reported landslides occurring outside of the monsoon season (i.e. October–March). This mirrors the temporal distribution of fatal landslide occurrences, documented previously by Petley et al. (2007).

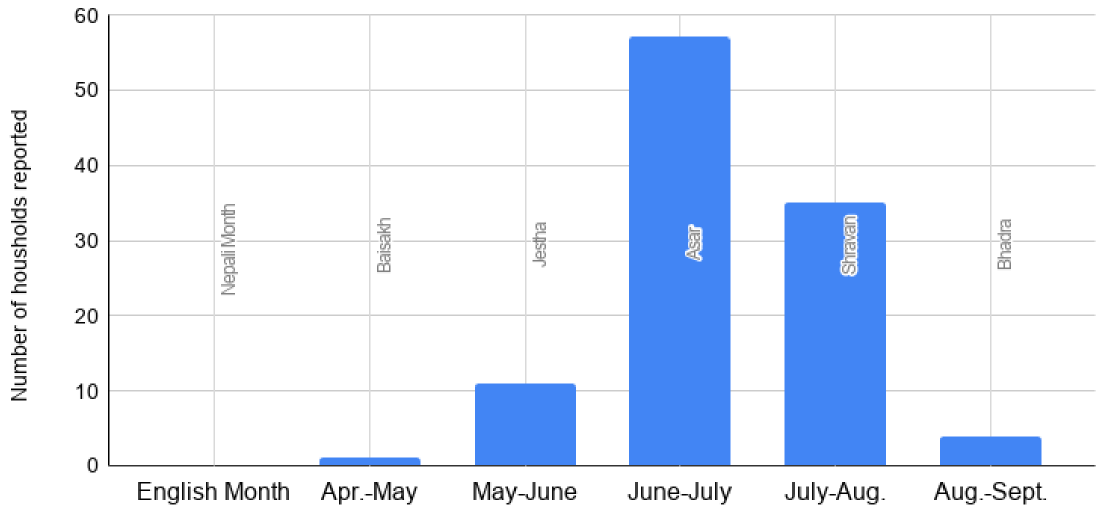


Figure 4-3. Seasonality of landslide occurrence according to the household survey responses.

Participants provided a coherent overview of periods considered susceptible to landsliding, often with week-by-week precision. Further to broader seasonal patterns (i.e. months as shown in Figure 4-3), respondents were asked to say which week had experienced the most landslide events in the valley. This confirmation of experience was aided by often very well organised sequences of farming-related activities in the monsoon that often fall in similar calendar weeks each year. Participants were also asked the following question: In what kinds of conditions do these landslides occur? (Q9, Appendix 6). In total, 11.9% of respondents said at least 24 hours of heavy continuous rainfall provided conditions for triggering landslides. Another 14.9% identified that two days of rains could trigger landslides in their village (Table 4-13) due to the excessively wet ground conditions. Only a small percentage of respondents viewed rainfall that lasted an entire week as a potential trigger factor for landslides. The highest number of respondents (i.e. 51.8%) identified 'other', with factors including improper rural road construction, no drainage along newly built roads, poor maintenance of farmlands, etc. In general, the ground conditions created by rainfall over varying lengths of time was the most commonly cited trigger factor for landslides. If the three main rainfall conditions were combined (24 hours of rainfall, 2 days of rainfall and rainfall that lasted an entire week), 27.0% of respondents consider excessive rainfall to be the main cause of landslides in their village. Among the case study locations, householders in Marming identified two days of rainfall (32.7%) as a potential cause of landslides in their village, whereas another 17.4% viewed only 24 hours of rainfall as significant.

Hindi sits on top of loose materials, and an active slow-moving landslide covers a large part of the village. The Chhyadi area, in which Marming is located, sits on the old deposits of historical landslides, which consist of loose materials. Most respondents here considered two days of continuous rainfall would be necessary to trigger landslides in this village, although their comments about the required rainfall intensity were not as precise. Some people considered conditions that would more likely trigger landslides would occur at the end of the monsoon period rather than earlier, and that these would be mainly associated with the attendant moisture and ongoing rainfall. It was clear that the understanding of the landscape's susceptibility to landslides and the amount of rainfall necessary to trigger them varied by location.

Table 4-13. Householders' responses with regard to the possible conditions for landslide occurrence in the valley

Possible conditions	On-road		Off-road		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
24 h continuous rainfall	9 (16.1%)	1 (3.7%)	1 (2.8%)	9 (18.4%)	20 (11.9%)
2 days continuous rainfall	3 (5.4%)	3 (11.1%)	3 (8.3%)	16 (32.7%)	25 (14.9%)
Rainfall lasting a week	1 (1.8%)	-	1 (2.8%)	-	2 (1.2%)
After monsoon	3 (5.4%)	-	2 (5.6%)	3 (6.1%)	8 (4.8%)
End of monsoon	2 (3.6%)	-	1 (2.8%)	1 (2.0%)	4 (2.4%)
Rural road construction	3 (5.4%)	-	-	-	3 (1.8%)
Other reasons	29 (51.8%)	19 (70.4%)	21 (58.3%)	18 (36.7%)	87 (51.8%)
No response	6 (10.7%)	4 (14.8%)	7 (19.4%)	2 (4.1%)	19 (11.3%)

(Source: Field survey, 2018).

A location's susceptibility to landslides includes various human-induced changes to the local landscape (Jaboyedoff et al., 2016; Sudmeier-Rieux et al., 2019), for example, fast-growing development works, which were frequently referred to by respondents. This includes ongoing and previous construction of hydroelectric power projects and local road construction, both of which can trigger new landslides or reactivate existing ones. In recent years, local road construction in the valley, colloquially referred to as '(bull)dozer engineering', has been reported as a significant contributor to landslides, echoing research from elsewhere in Nepal and beyond (Lennartz, 2013; Sudmeier-Rieux et al., 2019). In addition, householders often recalled the residual effect of the 2015 GE in the following monsoons and how this triggered further landslides. Householders observed the consequences of the 2015 GE and how these varied in the following two years (2016 and 2017; i.e.2073 and 2074 BS)), which were the worst in terms of landslides in the valley for some time. A few respondents, mostly older people, were also concerned that the relatively recent pattern of land abandonment had become increasingly prevalent in the valley, further accelerating landsliding.

4.3.6 Changing household understandings of landslide risk

As shown previously, householders often mentioned landslides they had observed directly. In the UBK, especially after the 2015 GE, a considerable change had been experienced immediately after the earthquake and, subsequently, there were further changes from the knock-on effects of out-migration, the reduction in trans-border trade, rapid local road construction and other development projects, including a hydroelectric power project. The out-migration of many economically active people from rural areas caused socio-economic and demographic changes in Nepal, notably in the UBK (Tamang, 2020). One of the consequences of this is that the local understanding of the landscape has diminished, both because of the loss of people who grew up in the valley, and because new people who know nothing about its past history have moved in. The transfer of knowledge and sharing of information between those familiar with the surroundings of the valley are invaluable in maintaining an awareness of what is hazardous and where the problems are (Lennartz, 2013). In such a context, the way in which householders have viewed the changing landslide hazard and risk over time after the 2015 GE is paramount in implementing any DRR activities at the community level.

In the previous sections, and specifically in Table 4-7, over 87.5% of householders reported their own direct experience of exposure to new landslides that had developed after the 2015 GE. Householders were also asked the following question (Q13, Appendix 6): Do you think that landslide risk has increased since the 2015 earthquake in the following locations (the *gaunpalika* and the UBK)? Of the respondents, 89.3% agreed that landslide risk has increased in their village (Table 4-14). Likewise, 90.5% of householders agree that the *gaunpalika* has also experienced increased landslide hazards and risks, followed by 89.9% of respondents who agree that the UBK has seen increased landslide hazards and risks. In contrast, 3.6% of respondents believe that landslide hazards and risks have not changed in either village, in the *gaunpalika* or down in the valley. Mapping from satellite imagery shows a dramatic increase in landsliding in these areas from the day of the earthquake in 2015 (e.g. Kincey et al., 2021).

Table 4-14. Perceived changing landslide hazards and risks after the 2015 Gorkha earthquake at village, *gaunpalika* and valley level

Has landslide risk increased after the 2015 Gorkha earthquake?	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
Own village					
Yes – has increased	52 (92.9%)	24 (88.9%)	30 (83.3%)	44 (89.8%)	150 (89.3%)
No – has not increased	-	2 (7.4%)	1 (2.8%)	3 (6.1%)	6 (3.6%)
Don't know	4 (7.1%)	1 (3.7%)	5 (11.1%)	2 (4.1%)	12 (7.1%)
Gaunpalika					
Yes – has increased	52 (92.9%)	24 (88.9%)	31 (86.1%)	45 (91.8%)	152 (90.5%)
No – has not increased	-	1 (3.7%)	2 (5.6%)	1 (2.0%)	4 (2.4%)
Don't know	4 (7.1%)	2 (7.4%)	3 (2.8%)	3 (6.1%)	12 (7.1%)
UBK					
Yes – has increased	52 (92.9%)	24 (88.9%)	31 (86.1%)	44 (89.8%)	151(89.9%)
No – has not increased	-	1 (3.7%)	2 (5.6%)	1 (2%)	4 (2.4%)
Don't know	4 (7.1%)	2 (0%)	3 (2.8%)	4 (4.1%)	13 (7.7%)

(Source: Field survey, 2018).

Respondents' observations of the landslides in roadside settlements included worries about coseismic cracks, albeit out of sight and above their village location. There was also reference to ongoing creeping: 'the landmass is already in [a] moving condition' (*jamin laskera baseko chha*). In off-road locations (Marming and Listi), householders associated weakened ground with ongoing development work, including blasting (Marming), and the constant slow creeping movement of the local landscape, particularly in the middle of the village. In Hindi, householders were concerned about an ongoing earth flow in the village. In Larcha, the landslides occur continuously all around the village, along the highway and around the Bhairav Kunda Khola that flows through the settlement. The Wordle infographic in Figure 4-4 shows the main signs of concern that local householders identified, and was drawn according to the responses to the question: What are the main causes or trigger factors for landslides in the village? (Q7, Appendix 6). The presentation with scaled text is qualitative.

Several respondents identified that landsliding might become more common where farmland has not been maintained. Small slumps on farmland may increase the future risk of larger landslides. For example, an 80-year-old man in Pokhari (in Marming) said: 'new generation left agriculture, so landslide has been increasing in these years' (*naya pustale kheti garna chhadyo, pahiro* *badhdai gayo*). He added: 'many people went to foreign countries, many left for Kathmandu and schools, so the land becomes abandoned' (*naya pustaharu bidesh gayo, kohi Kathmandu tira chha, utai baschha, ketakethi haru school janchha, kheti gardaina, jamin bajhiyo*).

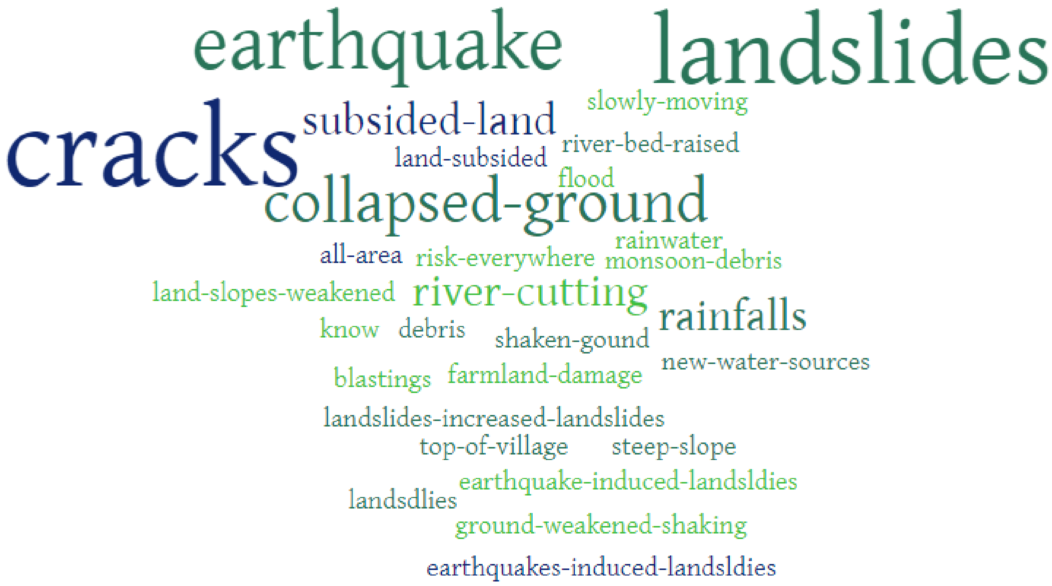


Figure 4-4. Wordle of landslide-related concerns, scaled according to the frequency of repetition.

4.3.7 Anticipating future landslide hazards and risks

The impact of landslides on a household depends on the combined effects of their timing, size, extent, severity and duration (Thapa and Adhikari, 2019). The anticipation of future landslides that could harm a householder also depends on householders' approach to reducing risks (UNISDR, 2015; Hernández-Moreno and Alcántara-Ayala, 2017). The previous section explored people's awareness of the geographical distribution, approximate size or extent and seasonality of landslides. The household survey was conducted after the 2015 GE, and as a result, the responses may have been significantly influenced by the experience of this event and the period since. According to the *gaunpalika* profile (Bhotekoshi Gaunpalika 2019a, 2019b), in the UBK, directly or indirectly, almost all the householders were affected by the earthquake, losing a family member or suffering damage to a building, if not its destruction. From my survey, the majority of respondents appeared aware of the potential future impact of landslides on their homes and families. However, a more precise view was difficult to delineate and associate with an individual's previous experience, the reason being that it was uncertain whether damage reported was caused by the earthquake or by landslides triggered by it.

The anticipation of future risk concerns the possibility of landslides over various timescales. The results (Table 4-15) show that in the next 12 months, 17.9% of respondents viewed landslides as ‘certain 100%’, 47.0% thought them ‘very likely’, 14.9% ‘quite likely’, 3.0% ‘quite unlikely’ and less than 1.0% thought their occurrence was ‘very unlikely’. If the responses under the categories ‘certain 100%’ and ‘very likely’ are combined, 64.9% of the respondents predict a ‘very high likelihood’ of future landslides (Figure 4-4). The pattern of response is very much uniform when aggregated across all communities surveyed.

Table 4-15. Respondents’ views on the likelihood of landslides occurring in the future

Likelihood of landslides within a given time period	Within 12 months	5 Years	Any time in future
	n (%)	*n* (%)	*n* (%)
Households (*n*)	168	168	168
Certain 100%	30 (17.9%)	39 (23.2%)	35 (20.8%)
Very likely	79 (47.0%)	67 (39.9%)	72 (42.9%)
Quite likely	25 (14.9%)	27 (16.1%)	28 (16.7%)
Unlikely	5 (3.0%)	2 (1.2%)	5 (3.0%)
Very unlikely	1 (0.6%)	2 (1.2%)	1 (0.6%)
Don’t know	15 (8.9%)	21 (12.5%)	12 (7.1%)
No response	13 (7.7%)	10 (6.0%)	15 (8.9%)

(Source: Field survey, 2018).

In the case of longer-term landslide risk (within the next five years), over 23.2% of respondents consider there to be a ‘certain 100%’ probability of landslides in the area. Additionally, 39.9% regarded the probability as ‘very likely’, 16.1% ‘quite likely’ and 1.2% ‘unlikely’ and ‘very unlikely’ (see Table 4-15 and Figure 4-5). Moreover, if the responses under the ‘certain 100%’ and ‘very likely’ categories are combined, 63.1% of respondents consider there to be a high likelihood of landslides within five years. For ‘any time in future’ or beyond, 20.8% of respondents were ‘certain 100%’, 42.9% respondents thought the probability ‘very likely’, 16.7% ‘quite likely’, 3.0% ‘unlikely’ and less than 1% ‘very unlikely’.

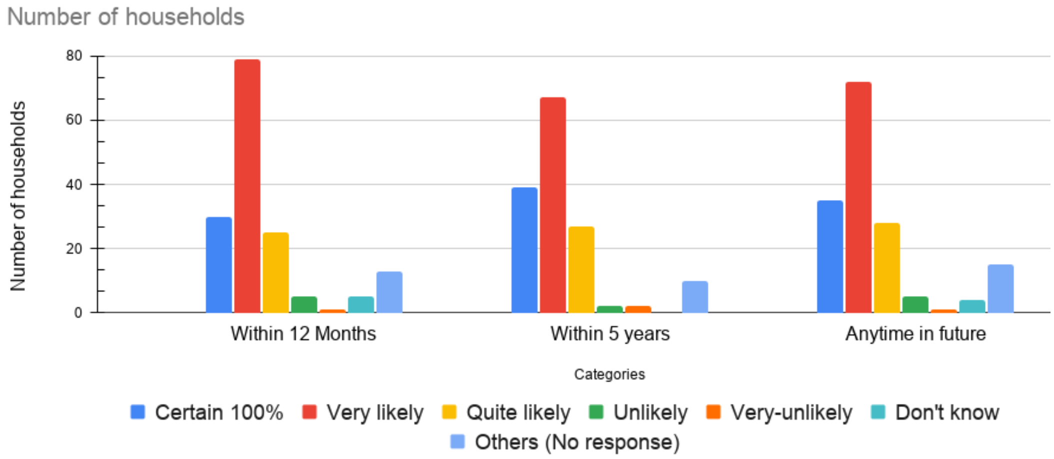


Figure 4-5. Respondents' views on the likelihood of landslides occurring within one year, five years and any time in the future.

In a comparison between on-road and off-road locations (Table 4-16), Hindi and Marming had the highest proportion of respondents who reported a high level of landslide risk in the near future (i.e. within one year). In Larcha and Listi, respondents categorise this as 'very likely', but not 'certain 100%'. This result perhaps mirrors the experience of landslide events over the past few years in each of these locations. The highest proportion of respondents suggested there would be a greater possibility of reactivating old landslides, including those triggered by the 2015 GE.

Table 4-16. Respondents' understanding of the likelihood of landslides occurring within the coming year

Likelihood of landslides occurring within 12 Months	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (*n*)	56	27	36	49	168
Certain 100%	13 (23.2%)	5 (18.5%)	1 (2.8%)	11 (22.4%)	30 (17.9%)
Very likely	23 (41.1%)	13 (48.1%)	12 (33.3%)	31 (63.3%)	79 (47.0%)
Quite likely	14 (25%)	2 (7.4%)	7 (19.4%)	2 (4.1%)	25 (14.9%)
Unlikely	1 (1.8%)	-	2 (5.6%)	2 (4.1%)	5 (3.0%)
Very unlikely	-	-	1(2.8%)	-	1 (0.6%)
Don't know	1 (1.8%)	2 (7.4%)	2(5.6%)	-	5 (3.0%)
No response	4 (7.1%)	5 (18.5%)	11(30.6%)	3 (6.1%)	23 (13.7%)

(Source: Field survey, 2018).

In terms of direct impact on their household, on average, 86.4% of respondents expected their family would be affected, and 9.1% did not expect a direct impact (Table 4-17). In a comparison between communities, this understanding of future impact ranged between 96.3% in Larcha (on-road) to 71.9% in Listi (off-road).

Table 4-17. Respondents' understanding of the possible impact of landslides on their families in the coming year

Predicted direct impact in future	On-road location		Off-road location		Total
	Hindi	Larcha	Listi	Marming	
Households (n)	56	27	36	49	168
Yes	46 (90.2%)	26 (96.3%)	23 (71.9%)	38 (86.4%)	133 (86.4%)
No	4 (7.1%)	1 (3.7%)	6 (16.7%)	3 (6.1%)	14 (9.1%)
Don't know	1 (1.8%)	-	2 (5.6%)	3 (6.1%)	6 (3.9%)
No answer	5 (8.9%)	-	5 (13.9%)	5 (10.2%)	15 (9.7%)

(Source: Field survey, 2018).

The household survey also explored the nature of the impact of future landslides (Q16, Q17, Q18, Appendix 6) by asking about possible adverse effects. The responses could include casualties, loss of assets/property or disruption. The results are shown in Table 4-18, which shows that about 44.0% of respondents see the potential for fatalities, 33.0% injuries, 44.6% loss of farmland, 26.8% damage to houses and 25.6% damage to crops. Moreover, respondents identified the potential for loss of community infrastructure, including water supply (2.4%), roads (3.0%), electricity (<1.0%) and others (7.1%). Thus, perhaps unsurprisingly, there were more serious concerns expressed about the loss of life and household assets rather than community infrastructure.

Table 4-18. Local understandings of the adverse impact of future landslides at the household level

Perceived impact on own household	On-road		Off-road		Total
	Hindi	Larcha	Listi	Marming	
Households (n)	56	27	36	49	168
Fatalities	21 (37.5%)	14 (51.9%)	12 (33.3%)	27 (55.1%)	74 (44.0%)
Injuries	17 (38.0%)	8 (30.0%)	4 (11.0%)	23 (48%)	52 (33.0%)
Loss of farmland	26 (46.4%)	13 (48.1%)	9 (25%)	27 (55.1%)	75 (44.6%)
Loss of home (buildings)	14 (25.0%)	5 (18.5%)	10 (27.8%)	16 (32.7%)	45 (26.8%)
Loss of crops	19 (33.9%)	9 (33.3%)	7 (19.4%)	8 (16.3%)	43 (25.6%)
Disruption to roads	3 (8.0%)	1 (4.0%)	1 (3.0%)	-	5 (3.0%)
Disruption to water supply	2 (3.6%)	-	1 (2.8%)	1 (2.0%)	4 (2.4%)
Disruption to electricity supply	- -	- -	1 (2.8%)	- -	1 (0.6%)
Others	6 (10.7%)	4 (14.8%)	1 (2.8%)	1 (2%)	12 (7.1%)

(Source: Field survey, 2018).

Villagers' seasonal and spatial anticipation of landslide hazards and risks and the impact they have emphasises their understandings of their valley's dynamics and, potentially, highlights areas for which their own observations intersect with formal data. Thus, further information or data on future landslide hazards and risks are made available, and this may improve the future selection of mitigation and preparedness approaches.

4.3.8 Managing landslide risk

The hazardscape has changed over recent years in the UBK. In this context, household engagement in LRM has been assessed, particularly with regard to people's willingness and ability to carry out and participate in risk reduction activities. In response to asking whether a householder had taken any measures to mitigate landslide hazards and risks, only 11.9% replied in the affirmative (Table 4-19), whereas 81.0% of householders had not put any mitigation measures in place; another 7.1% did not respond to the question. There are no major differences between case study communities with regard to the frequency of actions taken to protect their homes or property against landslides. Among those who have taken part in such activities, the measures identified included the following: channelling runoff (1); constructing retaining walls (7); planting trees (1); building gabion walls (5); and *puja-aaja* (worshipping) (1). People also mentioned bamboo and *amriso* (tiger grass, broom grass) plantations as a means of informal bioengineering. In addition, respondents mentioned that masonry walls, retaining walls and gabions (*taar-jaali तारजाली*) were mainly used along roads. Traditional measures, such as maintaining drainage, were not mentioned or were not regarded as having any benefit as a means of mitigation.

Table 4-19. Measures taken by householders to protect their homes from landslides

Measures taken at household level		On-road location		Off-road location		Total
		Hindi	Larcha	Listi	Marming	
Have any measures been taken to mitigate landslide hazards and risks?	Households (*n*)	56	27	36	49	168
	Yes	7 (12.5%)	3 (11.1%)	4 (11.1%)	6 (12.2%)	20 (11.9%)
	No	45 (80.4%)	24 (88.9%)	30 (83.3%)	37 (75.5%)	136 (81.0%)
	No answer	4 (7.1%)	-	2 (5.6%)	6 (12.2%)	12 (7.1%)

(Source: Field survey, 2018).

About 10.7% of householders said they could pay for landslide mitigation from their own household income (Table 4-20). The remaining 89.3% reported either 'no' (unable to spend money), or they were unaware of the resources required for such measures.

Table 4-20. Householders' ability and willingness to use financial resources to protect property against landslide hazards and risks

		On-road		Off-road		
		Hindi	Larcha	Listi	Marming	Total
Able to spend money protecting own home and farmland	Households (n)	56	27	36	49	168
	Yes	7 (12.5%)	3 (11.1%)	4 (11.1%)	4 (8.2%)	18 (10.7%)
	No	40 (71.4%)	22 (81.5%)	25 (69.4%)	26 (53.1%)	113 (67.3%)
	Don't know	3 (5.4%)	1 (3.7%)	-	12 (24.5%)	16 (9.5%)
	No response	6 (10.7%)	1 (3.7%)	7 (19.4%)	7 (14.3%)	21 (12.5%)

(Source: Field survey, 2018).

Additionally, when householders were asked if they could devote any non-monetary resources to landslide mitigation measures, for example, providing logistics (e.g. portering materials, collecting stone, exchanging labour) or using their own labour, 20.2% (34 householders) said they could protect the family and property (Table 4-21; ref. Q23a, Appendix 6). The sums or equivalent values respondents suggested could be involved ranged from the salary or income for a week or a month, to a far larger fixed amount. Of the respondents, 13.7% (23) said that supporting the logistical costs was considered the easiest way of offering resources, for example, exchanging labour, collecting stones and being involved in labour work directly. Only nine householders (5.4%) said that their family could afford an equivalent of one month's income for landslide risk mitigation within the period of a year. Despite the willingness to contribute, the householders expected technical assessments and external support to be provided by the government when they were in need of risk reduction measures.

Table 4-21. Householders' ability and willingness and to contribute to landslide risk mitigation efforts

Allocating household resources	On-road		Off-road		Total
	Hindi	Larcha	Listi	Marming	
Households (n)	56	27	36	49	168
One week's salary (a)	-	-	1	-	1 (0.6%)
One month's salary (b)	4	1	4	-	9 (5.4%)
Fixed amount (c)	1	-	-	-	1 (0.6%)
Others (logistical) (d)	3	2	1	17	23 (13.7%)
(a+b+c+d) = all resources	8	3	6	17	34 (20.2%)

(Source: Field survey, 2018).

However, it should be noted that when looking at Table 4-21, householders' willingness and ability to devote resources to landslide mitigation measures (Q19b, Appendix 6) were perceived to have technical limits. For instance, the practice of sealing of cracks associated with landslides is believed to be impossible to achieve within the limits of available household resources. In addition, the costs understood to be involved in mitigation measures, and the worries associated with the extensive nature of landslides, meant that many felt landslides could not be mitigated on a grassroots level.

4.4 Discussion

The findings from this study show that everyday hazards and risks receive a relatively high degree of attention from people living in the UBK. They are one of householders' main priorities, and their perceptions are influenced by the multi-dimensional impact they have, the lived experience of landslides, people's awareness of them, direct observations and the changing nature of landslide hazards and risks. I further investigate these themes that have emerged from my analysis below by summarising the key observations and exploring these in the broader context of previous research. I base my discussion around the following:

1. Local understandings of everyday hazards and risks, and the significance of landslides;
2. Lived experience and knowledge of landslides;
3. Changing understandings of landslide risk;
4. Anticipating future landslide risk;
5. Managing landslide risk.

4.4.1 Everyday hazards and risks and knowing the location and characteristics of landslides

This study has highlighted the pressing everyday problems faced by householders in the UBK, with a focus on landslides. Throughout the survey, the intention was to comprehend household understandings of people's perception of hazards and risks under different themes. Everyday facilities and livelihood support mechanisms have the highest priority among householders, but landsliding remains a prominent concern for the overwhelming majority. From the results above, the hazards experienced by a household can be a significant component of daily life, as observed elsewhere (Wagner, 2007). For instance, drinking water ranked as the first daily concern among most respondents, with access to roads and health facilities cited by others, reflecting strategies for addressing the most pressing needs (Sudmeier-Rieux et al., 2012). I have also highlighted here that these needs can change, for example, in response to the reduction of farming activities because of out-migration.

Several recent landslides in the UBK have had severe consequences, especially the 2015 GE (Kincey et al., 2020; Rosser et al., 2021). The household survey shows that, accordingly, landslide hazards and risks have become a significant recent priority, commonly featuring as a householder's first, second or third highest concern. The perceived risk could be based on the degree to which respondents' socio-economic conditions enable them to make choices (UNDP, 2009; Acosta et al., 2016). For instance, damage to livelihoods caused by loss of farmland can leave reconstruction unaffordable, especially for the poorest households. Knowing the location of landslides, and their size and type has been shown here to have an important role in informing householder preparedness and mitigation (Oven and Rigg, 2015). The implication is that only by understanding the hazard context can attempts be made to address the root causes (Oven and Rigg, 2015). The most common impact of landslides identified by householders was disruption to daily life. This includes the effect on regularly used walking trails, daily commuting routes to farmland, for fodder collection, grazing routes and access to schools and health facilities.

Householders' in-depth knowledge of their own environment articulated a good awareness of nearby landslides. The identification of landslide locations and simple categorisations can have a significant impact on pinpointing hazardous and non-hazardous areas. Such impressions were more accurate when householders were describing readily visible locations with which they had daily interactions, for example, adjacent to walking trails or roads. In less visible and/or more distant locations, this assessment became less precise. This observation highlighted that householders may have limited knowledge of the sources of hazards in distant places or those beyond their observation range, such as places located on the hill or down in the valley. Crucially, in cases in which landslides can travel long distances, this may represent a critical gap in people's awareness of the risks that they face. At the time of the survey, householders in Marming and Listi (off-road locations), which are located on the middle and higher slopes of the valley, perhaps have a clearer daily view of a wider area and, hence, potential sources of landslides. Conversely, on-road (Larcha and Hindi) communities have quite restricted views within the confines of the valley bottom, and so see only the landslides along the highway.

Like Oven's (2009) study, this research has confirmed that communities have a high level of knowledge of landslide hazards. Based on the descriptions provided by householders, in general, the local population have a good knowledge of the slopes on which they live and the causal and trigger factors for landslides. Large landslides received a higher priority in the responses compared with slow-moving or creeping masses, or (apparently) less threatening landslides. Creeping slopes (*jamin bistarai bagne जमीन विस्तारै बग्ने* very slow movement of the landmass) were not seen as a priority because they were a longer-term threat. The householder responses show a good degree of knowledge, particularly in recognising slow-moving events as hazardous. This counters observations elsewhere, which have found that understandings of similar slow hazards are limited, and that those who could potentially be affected find this aspect of landslide hazard a challenge to comprehend (Solana and Kilburn, 2003).

My results show that most households in the UBK have a high level of awareness of landslide-prone areas. Inevitably, householders' experiences were affected by the current local conditions (Slovic, 1987; Bustillos Ardaya et al., 2017). For instance, cracks, landslides along the river and landslides located close to farmland where the situation has evolved actively after the 2015 GE, were all identified currently as problematic. The awareness of underground conditions and other underlying more mechanical causes was mentioned less often, if at all. For example, practically no one discussed the sub-surface conditions or geological conditions common to landslide locations; on the contrary, there was a much greater focus on the surface situation and how this had been influenced by the earthquake and subsequent heavy rains. Hazard awareness is clearly also more sensitive to currently active landslides, such as those associated with the Chhyadi Khola, Chaku Khola and Larcha (Bhairav Kunda Khola) and recent debris flows in these channels, which all have the potential to be destructive, than it is to slower or apparently dormant landslides.

Household assessments of the potential risk to houses can be determined by the residents' detailed knowledge of hazardous locations, their proximity to the landslide, its likely future impact and its historical recurrence (Zhang et al., 2010; Lujala et al., 2015). Similarly, during the survey, it was commonly observed that the proximity of a householder to a landslide was associated with a higher degree of concern, or in other words, a high degree of awareness of perceived personal exposure to hazards (Lindell and Perry, 2003; Dekens, 2007). Such judgements of risky locations were made by householders and consistently related to the potential consequences for themselves, their neighbourhood and their daily commuting area. The list of specific areas of concern documented in the household survey (Table 4-8 and Table 4-9) mentioned specific landslide names and villages or areas, and implied that the accuracy of understandings of risks became less precise the further the distance from areas frequented by the respondent.

Household awareness of the seasonality of landslides (or seasonal risk or exposure) was closely associated with seasonal rainfall patterns. Householders recognise this pattern because, seemingly, it is based on their experience of changing rainfall conditions throughout the year, which are known to be aligned with the general pattern of landslides and floods in Nepal (Petley et al., 2007; DesInventar Nepal, 2017). Moreover, householders were also able to pinpoint which weeks were often more prone to landslides. However, the intention was not to use the answers to officially validate their opinions, but to see if they related changing landslide risks to week-by-week activities in the monsoon period, for example, cropping. The most widespread implication of seasonal exposure to landslides was that householders adopted seasonal strategies to enable them to adapt to various kinds of stress at the family level (Dekens, 2007), which are aligned with the seasonal calendar, for example, times when people are seeking alternative sources of income or planning farming activities. During the monsoon, the impact of rainfall was often noted by householders as a potential threat, with the closure of local walking trails being commonplace after intense precipitation. For example, Saili/ c. 40y/f stated: 'trail going to Marming might close if there is overnight rainfall'. Therefore, householders' understandings of the seasonality of the landslide threat are essential for reducing risk, because local activities such as travel to the market centre or health facilities are planned over the most suitable timescales.

In terms of trigger factors, rainfall was reported as the most important by over 53% of respondents in the UBK. This view is very much related to seasonal patterns in landslide activity, as reflected by Nepal's national datasets on the impact of landslides (BIPAD Portal, 2021; DesInventar, 2021). General forecasting of landslide trigger factors by householders is challenging, but can be very helpful in recognising the broad rainfall conditions that could lead to landslides. Such understandings could provide a basis for formal or informal monitoring of slopes around villages and could be used to define (semi-)empirical thresholds beyond which it would be important to increase local community awareness about landslide trigger factors. Such local knowledge can also be used in household planning, particularly in local assessments of the timing of likely seasonal landslide risk. Knowledge of trigger factors has been vital in minimising exposure to future risks (Milledge et al., 2018), for example, in relation to deciding where to build so that exposure to potential future landslides is reduced.

4.4.2 Lived experience of landslides

In recent years, a series of high-magnitude hazard events have been experienced in the UBK, especially landslides and floods, which have apparently been aggravated by the 2015 GE (Cook et al., 2018; Liu et al., 2020; Rosser et al., 2021). In the sections above, the survey results show that householders generally prioritise their everyday concerns or worries based on their lived experiences of hazards, especially in landslide-prone areas. The results illustrate how householders' attitudes towards landslide hazards and risks underpin their experience and shape their knowledge of evolving situations (Stewart and Lewis, 2017; IFRC, 2020). For example, cracks were the most common visible signs of unstable slopes mentioned by householders (Figure 4-3).

Householders' lived experience (over 87.5%, see Table 4-8) of landslides in the UBK and the anticipation of an increased intensity of landslide hazards and risks has continued after the 2015 GE. The apparent future threats from landslides were illustrated in relation to two consecutive years' experience after the earthquake, during which communities witnessed a severe impact on the UBK. Moreover, the accounts given involved extensive knowledge of the sources of landslides. For example, in the present context, villagers were engaged in reconstructing their houses after the 2015

GE, but any kind of technical assessment of the building plots' ground conditions and exposure to landsliding was generally absent. General guidance from the government was available through the NRA, but householders remained generally unaware of the ground conditions. The expectation of householders that the suitability of the ground for building would be assessed was often mentioned in conversations, and they believed such assessments should be provided by local government authorities.

Householders often mentioned living with uncertainties was a concern, but there were notable differences between respondents. For instance, families that had lived in off-road locations for generations may have been more familiar with landslide hazards and risks than those living along the road in the valley bottom. However, in the current post-earthquake circumstances, a higher proportion of people who had formerly lived in off-road locations may have more recently relocated to the valley bottom for business purposes. It was found during the survey that the majority of householders living in on-road locations had originated from elsewhere in the valley; therefore, the distinction between off-road and on-road communities was perhaps less stark than expected. Prior to the 2015 GE, the diversity in the population, which often consisted of people from many different parts of Nepal living in on-road areas, could have led to a generally limited knowledge of potential local hazards beyond those experienced every day, or how such hazards had changed or could potentially change over time.

4.4.3 Understandings of the changing nature of landslide hazards and risks

The understanding of landslide hazards and risk in the UBK closely mirrors examples from the literature; notably, it highlights the association with local road construction, development works and out-migration (e.g. O'Neill, 2004; Wagner, 2007; Oven, 2009; Lennartz, 2013; McAdoo et al., 2018; Vuillez et al., 2018; Sudmeier-Rieux et al., 2019; IFRC, 2020; Oven et al., 2021). Further, the at times overwhelming experience of several high-magnitude hazard events in the UBK over the past years, including the Jure landslide in 2014, the 2015 GE (2015) and the catastrophic glacial and landslide dam flood events in 2016 and 2017, resulted in heavy losses in the valley. In addition, incremental slow-onset landslides caused by cracks created by the earthquake may also have increased the UBK's vulnerability to future landslides after levels of rainfall that were previously safe (Moser, 2010). In such a context, householders view these events as having the potential to cause considerable loss to property and more casualties in the valley in the future. Again, this can be related to the perceived risk, principally influenced by past experience (Bustillos Ardaya et al., 2017). Thus, householders' local interpretations of changing risk are different before and after the 2015 GE.

Protecting their lives and property given such changing hazards and risks was challenging for householders, with constraints mainly expressed in terms of the costs of mitigation and the availability of technical support. Most householders were just recovering from the earthquake, and struggling with the financial resources necessary to aid reconstruction, so further landsliding is an unwelcome additional burden. Only about 20% of respondents saw themselves as able to spend money on landslide mitigation, whereas about 80% struggled to support their daily household needs. In such a way, despite people recognising hazards as present and even their increasing nature, mitigation measures are beyond the means of most. Moreover, in the Ghunsa neighbourhood (in Marming) and the Gumba neighbourhood (in Listi) two examples for which people expected substantial help from outside, primarily the government, were described. In Gumba, householders were involved in various negotiations with the authorities about the GHA conducted after the earthquake (Oven et al., 2021), but no follow-up action had as yet been taken.

In Marming, respondents were worried about a large boulder that had recently appeared in the Chhyadi Khola, which flows next to the village, apparently posing a threat. In such a context, the risk posed by the changing and dynamic nature of the hazard in the valley presents householders with multiple concerns and there is the potential for the situation to have an impact on their livelihoods. Conversely, just experiencing a hazard does not mean that people necessarily can or do adopt safe(r) behaviour (O'Neill, 2004). For instance, views obtained from conversations show that choices are often constrained: 'we have reconstructed our houses at the same places as we don't have the alternative place to move'. Decision-making with regard to avoiding landslide hazards and risks in such a context remains within the choices available.

4.4.4 Predicting future landslide hazards and risks

Predicting future landslide hazards and risks is an important aspect of risk management that informs how households foresee and understand future threats, and how these are weighed against other needs. This creates awareness about landslide locations and types, and the future risks they pose, influencing the choice of preventative measures (Chester et al., 2008) and the planning for immediate and long-term actions. Therefore, landslide prediction or minimal monitoring is potentially important in providing information vital for reducing household damage and potential losses (Chae et al., 2017). For example, monitoring could include measures of landslide growth that might give an indication of how long it will be before land becomes unworkable. Again, householders' responses (Section 4.3.7; see Table 4-15, Figure 4-5) demonstrate that people understand the seasonality of risks related to the months of *Asar* and *Shravan* (June–August). Therefore, householders' general anticipation of risk is entirely based on their own experiences rather than on information shared with them that comes from a wider group of stakeholders or from other groups outside the UBK such an experts or NGOs.

In anticipating landslides within the coming year, five years or over an even longer period, householders showed consistency in their responses, with nearly all expecting there to be landslide events on the horizon over all time scales. This suggests a sizeable proportion of the valley population is aware of the landslide risk based on experience, but also do not see the situation necessarily improving as the length of time since the earthquake increases. This risk assessment is vital for householder preparedness and mitigation (Wagner, 2007; Klonner et al., 2016, 2018). The successful anticipation of the consequences of landslides is seen as being influenced by several factors including their location, timing, size, extent, severity and duration (Thapa and Adhikari, 2019). Moreover, such anticipation relies on having the skills to judge local phenomena, including local slope, landslide trigger factors, duration of rainfall intensity and the wider seasonality of the rainfall pattern (Chae et al., 2017). Although such an assessment might not necessarily align with scientific predictions or modelling, the knowledge can be used to minimise uncertainty and raise awareness locally (Hearn and Hart, 2011; Hearn et al., 2016).

4.4.5 Managing landslide risk

In terms of legal provision, to varying extents, LRM is the responsibility of a number of different government ministries (MoHA, 2017; Oven, 2019; Bhandari et al., 2020). Traditionally, the dominant approach to landslide hazard and risk management in Nepal has been response based and mainly conducted on an ad hoc basis, particularly by individual householders or communities (Oven, 2019). Thus, the challenges for LRM, particularly with regard to the poor knowledge of the underlying processes, are evident in cases in which householders suffer from a consistent underestimation of the magnitude of losses and consequences both in the short and long term (Damm et al., 2013). Such gaps in knowledge can be mitigated at least to some extent by a better understanding of the problem, facilitated by bringing together both local knowledge and that of experts (Pidgeon, 1998). In such a way, a better understanding of local risk has an important role to play in enabling the generation of better knowledge and the active engagement and development of local government expertise to work with communities in addressing the problems they face (Jones et al., 2013).

When considering Nepal's high exposure to landslides, managing landslide hazards and risks remains immensely challenging. At the local level, the proper mechanisms for LRM are almost totally absent, with minimal local capacity for risk assessment, mapping and monitoring, and other risk mitigation measures. Although examples have been cited in this study, LRM at ward level was yet to have been formalised when the survey was carried out, which reflects the recent changing federal government structure. The complexity of LRM in a governance context in which roles, laws and responsibilities are only just becoming clear is immensely challenging. A complex process such as risk identification and risk management (Alexander, 1991; Wachinger et al., 2013) is an ambitious target for a new structure that often does not have the basic technical expertise. Thus, LRM at the local level in communities was almost always a householder's business, rather than it being integrated into formal local government responsibility, and there was a limited understanding of mitigation measures possible or available. The household survey illustrates two primary strategies adopted in communities for the local practice of LRM: (a) household only; and (b) the household as part of a broader community.

Household LRM strategies primarily focused on household safety as the first step, that is, saving family, and their assets such as homes, farmland, livestock and shops. According to householders, ground that is slipping (creeping) can cause cracks in buildings (Hindi), which is widespread in many houses and on land too. Maintenance tended to consist of minor repairs to the house, for example, constructing masonry walls, and in the case of land, mitigation measures, such as draining rainwater away from farmland to protect it from further deterioration, that were within the capacity of household resources. These practices were mainly adopted based on local capacity, tradition and skills, rather than relying on any engineering or external technical support. Householders often complained about the lack of resources to mitigate the potential impact of hazards, but significant financial resources for more advanced, larger-scale or long-term mitigation measures are usually beyond the means of ordinary households.

Household involvement in risk management as part of community activities has been important in LRM. For instance, the local practices of horizontal channelling of runoff, construction of small masonry walls, yearly maintenance of village walking trails during Dashain (*dashai ma bato khanne दशैंमा बाटो खन्ने*) and managing/proper drainage of water running off the roof (*barkha ko bhalpani sojhyaune, kuleso katne वर्षाको भलपानीको व्यवस्थापन, झराली जाने, भल सोझ्याउने, कुलेसो काट्ने आदि*), were commonly mentioned as measures either knowingly or unknowingly helpful in protecting houses and farmland from landslides and other hazards such as erosion. A common view of householders was that traditional practices were disappearing because of an increasing reliance on new technologies such as gabions. Furthermore, the value of traditional or cultural practices for risk mitigation, such as worship and rituals commonplace in rural Nepal (Gurung, 1989; Jigyasu, 2002; Krüger et al., 2015), is more widely recognised in the literature (Bankoff, 2003; Chester et al., 2008; Krüger et al., 2015; Lee, 2016; Williams et al., 2018). Householders, especially elderly respondents, complained that cultural practices such as *naag puja* (serpent or snake worship *नागपूजा*), *shime bhume* (*shim(e)*) (waterspouts/ponds/water sources), *bhumi(e)* (land *puja*) and *sansari puja*s (nature worship, with villagers typically gathered in the jungles or near riversides), are not properly offered or conducted. In Marming, some householders mentioned that the Lamas (religious people) did perform some religious and ritual ceremonies (*mantra-padhne मन्त्र पढ्ने*) to try and prevent landslides next to the Chhyadi Khola, just above the village. Moreover, householder engagement in community action such as contributing *perma* (the traditional exchange of labour or services between neighbours *पर्म*), or belonging to *aama samuha* (mothers' groups) or community forest user groups, who each engage in DRR activities either directly or indirectly, were all potentially valuable community activities for managing the village landscape, but also played a role as lower-level mitigation measures for potential future landslide risks.

4.5 Summary

From the results above, householders commonly associate distinct reasons for landslides and their future impact with specific locations. Their views are shaped by direct knowledge and experience rather than knowledge that is passed on or exchanged between community members. As experienced in recent years, landslide hazards and risks have become more severe because of the 2015 GE. The earthquake has had a long-lasting impact on everyday hazards and risks, making the subsequent monsoon seasons riskier too. In the UBK, householders confirmed that earthquake-triggered landslides have become more frequent, individually more hazardous, and more extensively distributed; therefore, they capture a great deal more local attention. However, predicting and understanding their future impact remains a challenge. A small proportion of householders believed landsliding might settle in the coming years, when the cracks in the ground stabilise and it becomes less weak. Despite extensive landsliding, risk management in the valley has not been conducted in a systematic and institutionalised way, but remains ad hoc and is initiated only by the community. Although knowledge of landslides themselves is considerable, there is a much lower understanding of the risks they pose, and how these can be effectively reduced.

This chapter has explored community understandings of landslide hazards and risks from the household perspective. I now turn to consider how this understanding is reflected on a larger community scale and in a geographical sense, and use PMEs to facilitate this. From these, I aim to consider how the knowledge gained can contribute to the design of an improved means of landslide risk communication, envisaged as a physical model for use in communities.

Chapter 5

Mapping community understandings of landslide hazards and risks

5.1 Introduction

Spatial understandings of the most common landslide events and their processes and impact are fundamental for ensuring that mitigation measures at the community level are sustainable. One approach used in research and also increasingly in development projects for gaining insight into such geographical understandings is participatory mapping exercises (PMEs), which can give 'clear, factual understandings of their whereabouts for the first time' (Rambaldi, 2010, p. 15). Such an interactive approach can make a significant contribution to decision-making processes by providing a forum for discussion and collating and contesting different types of knowledge (Gaillard et al., 2013). Since the 1970s, PMEs have gained widespread recognition among development practitioners as a means of integrating the spatial knowledge accumulated by a local community with that held by experts, or local planners and decision-makers (Chambers, 1994; Rambaldi, 2010; Cadag and Gaillard, 2012; Gaillard et al., 2013). PMEs have demonstrated their potential for nurturing community dialogue involving multiple stakeholders (Gaillard et al., 2013).

In order to nurture community resilience to disasters, self-definition of the areas that are perceived to be hazard prone is important, notably if the community participates actively in designing risk reduction measures (Cadag and Gaillard, 2012). In this chapter, I try to explore community understandings of the geography of landslide hazards and risks using PMEs.

5.2 Aim and objectives of the chapter

This chapter aims to explore and assess the community's spatial and temporal understandings of landslide hazards and risks through PMEs. I use these exercises to consider the scale of landslide change post-2015 GE by using satellite imagery before and after the earthquake as the base maps for the mapping exercises. Moreover, the study is structured so that discussions can be captured and the contested understandings of landslide hazards and risks collated to form a consensus opinion about those aspects of their reality that are more uncertain or unfamiliar. Finally, I intend using this mapping approach to introduce formal scientific data and maps that describe landslide hazards and risks so I can assess how these are understood and contested.

To achieve my aim, I seek to answer the following research questions:

1. How do communities describe their spatial knowledge of landslide hazards and risks in map form?
2. Can PMEs be used to assess the perceptions of landslide hazards and risks across the landscape?
3. Finally, can PMEs be used as a means of risk communication through which local understandings of formal scientific data on landslide hazards and risks can be explored?

5.3 Methods

In this chapter, I use qualitative PMEs (Cadag and Gaillard, 2012; Gaillard and Mercer, 2012; Gaillard et al., 2013, 2016) to assess community understandings of landslide hazards and risks. PMEs are widely used to explore spatial understandings of hazards and risks, according to which features are identified, classified or categorised according to the perceived level of threat faced by communities. I designed a stepwise protocol for conducting PMEs with my case study communities, and in this section I describe the methods used for mapping, and for analysing the results. Figure 5-1 summarises the process I followed, and sets out how this chapter fits within the wider thesis and research.

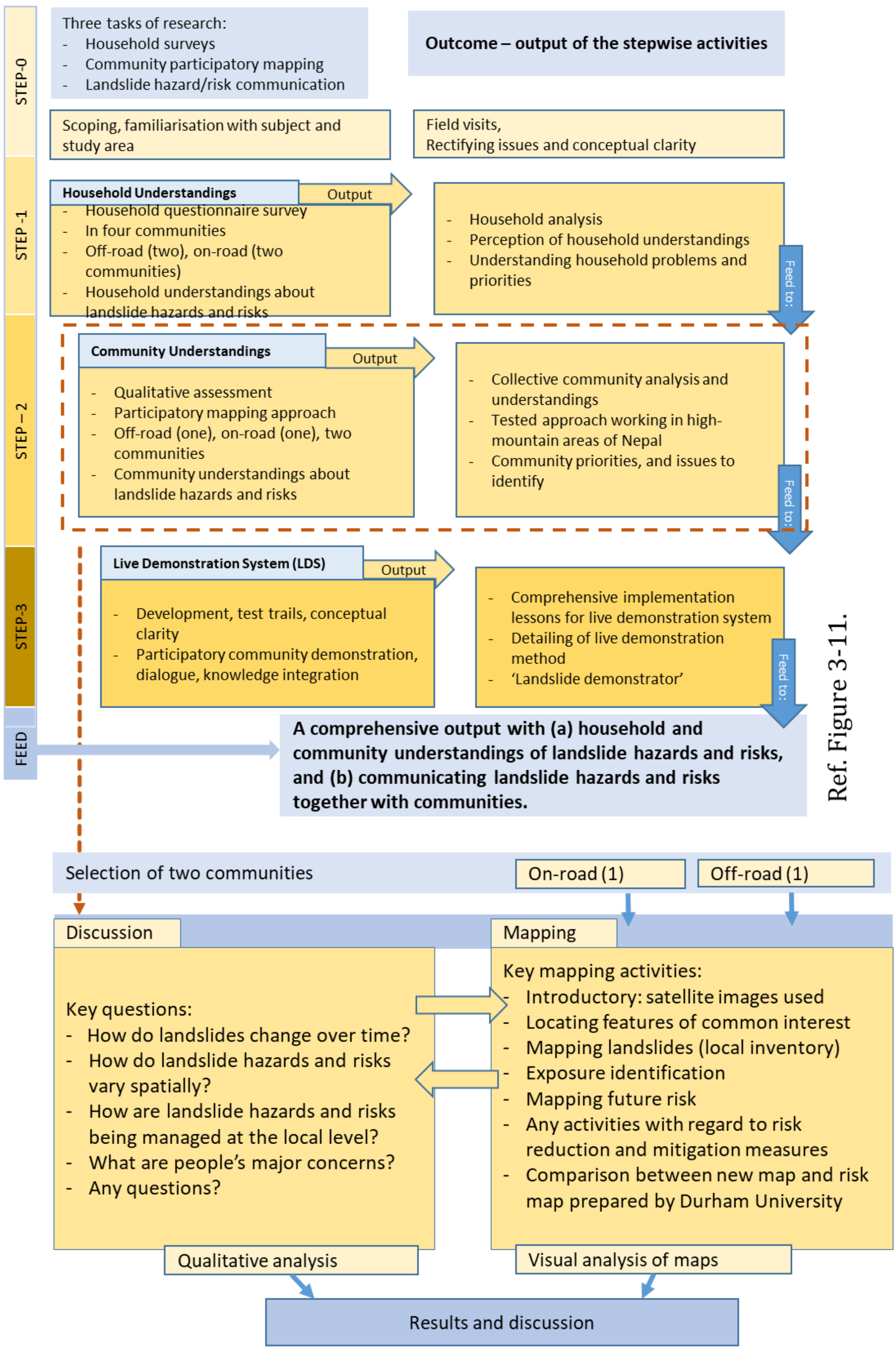


Figure 5-1. Methodological procedure: Showing how the activities described in Chapter 5 fit into the wider thesis research.

5.3.1 Materials for PMEs

In the following sections, I discuss the logistical arrangements for the PMEs.

1. Use of true-colour satellite images

The base maps for the PMEs were printed high-resolution satellite images. These were A0 size and covered a ground area of approximately 10 sq. km (4 x 2.5 km) around the two case study communities. The primary images for the exercise were (a) a pre-earthquake image (dated 14.04.12), and (b) a post-earthquake image (dated 17.09.12). Both were high-resolution (*c*.1 m), true-colour images from Google Earth. The better resolution and visibility of features on the ground in image (b) were used to cross-check observations that were made in the mapping, whereas image (a) was in effect used as a 'blank canvas', because landslides triggered by the 2015 GE (by far the majority) were not shown. Therefore, participants had a chance to evaluate their results and confirm their observations based on the more recent image. These forms of imagery are widely used in social science research for visualising the Earth's surface (Goodchild, 2008). The use of printed hard copies of Google Earth imagery in this exercise was based on positive experiences from previous research (Haynes et al., 2007; Gaillard and Mercer, 2012; Gaillard et al., 2013; Oven et al., 2017; Klonner et al., 2018). Among these, Haynes et al. (2007) explored the use of perspective photographs, aerial photographs in particular, to depict the local landscape in a more detailed and realistic context. In this example, the recognisable and highly visible nature of ground features in these high-quality images was found to be very useful when evaluating local people's perceptions of volcanic hazards with a variety of stakeholders, including community members, authorities and scientists.

2. Landslide risk map, prepared after the 2015 GE

One of the objectives of this part of my research was to explore local understandings of what is depicted by formal scientific landslide data and mapping and how this can be used to communities' advantage. In doing so, I used A0 size printed colour copies of landslide risk maps prepared by Durham University that track the changes to landslides after the 2015 GE (see Kincey et al., 2020). These maps were designed for the *gaunpalika* level to capture the changing landslide risk after the 2015 GE with the aim of supporting local authorities in their introduction of mitigation measures (Rosser et al., 2021), and include details on location footprints, changes and potential future risks. The PMEs presented a valuable opportunity to appraise the responses to these formal scientific maps, especially when they were presented alongside maps based on the Google Earth imagery. The Durham University landslide maps were used towards the end of the PME sessions to minimise their influence on the participants' own mapping (Figure 5-2). It should be noted that both types of map were introduced on an equal basis during any PMEs conducted at the local level. Neither was 'right' or 'wrong', or of a superior value in understanding the landscape.

Figure 5-2. Screenshots of two different map sets used during the participatory mapping exercises.

(a) Google Earth image used for participatory mapping exercise covering study community in Larcha, and (b) landslide risk map (shown alongside satellite images) covering the Bhote Koshi *Gaunpalika* (14 severely affected districts) prepared by Durham University after the 2015 Gorkha earthquake.

3. Interactive mapping symbols

Representing knowledge using a clear and consistent legend is an important component of PMEs. The aim is to codify participants' intuitive judgement without losing its meaning (Dekens, 2007; Bormudoi and Nagai, 2017; Peart, 2018). The design of the legend plays an influential role in how individuals or groups incorporate weightings or properties when mapping (Birkholz et al., 2014; Ribeiro et al., 2020). Using a consistent protocol for the legend is also important if the information gained from the PMEs is to be decoded efficiently during the analysis (Haynes et al., 2007). A simple and easily comprehendible system of representing local understandings when mapping was developed, and this was organised using a standardised key (see Figure 5-3 and Figure 5-4). Uniformity in representing community views was deemed to be important to allow comparisons between individuals and communities. To achieve this goal, Lego bricks were used alongside coloured sticky notes (Post-It Notes) to locate features, assign them a rank or weight and to represent participants' views and insights (Haynes et al., 2007, p. 136).

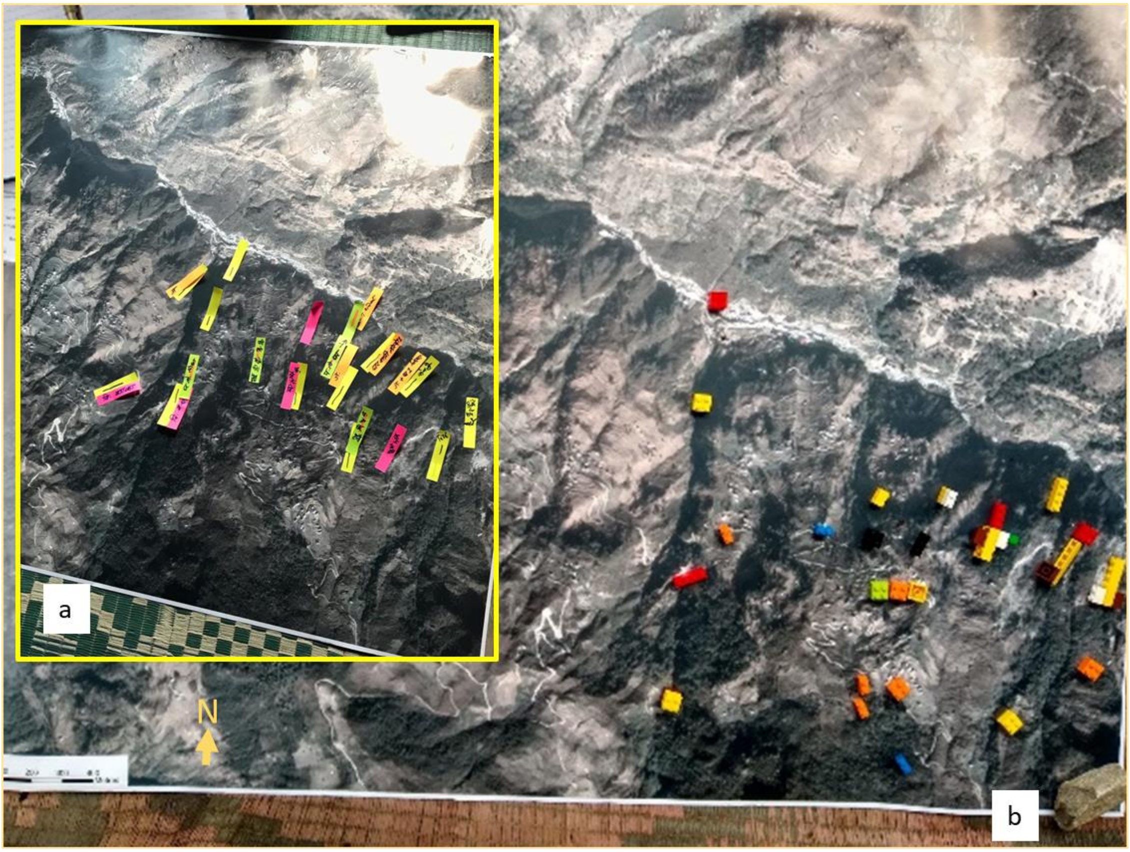


Figure 5-3. Use of interactive keys during participatory mapping exercise showing two different community experiences for the same area.

Map (a) inset, an initial trial of the usefulness of Post-It Notes in a mapping exercise in School dada, Marming, 25.06.2019, and (b) showing the use of Lego, which was utilised interactively to place initial thoughts before the layout was modified so that participants could reach a consensus (Chhyadi Gumba 28.06.2019). An explanation of the symbols according to size and colour of the Lego bricks is given in Figure 5-4.

Due to time constraints, Lego was an efficient means of representing features because it showed them distinctly and minimal skill was required to place the bricks on the map, as suggested in the literature (Williams and Dunn, 2003; Cadag and Gaillard, 2012). The features were categorised by participants according to their own assessment of the potential impact they might feel and the consequences. For example, first of all, a landslide location was pinpointed on the base map, then it was represented according to the landslide attributes (small, medium, large, which was represented by single, double and three-unit Lego bricks, respectively). The next level of the categorisation was assigning colour codes based on the perceived level of risk (blue, yellow and red for low, medium and high threat, respectively). The variety of available Lego bricks was helpful in representing a wide range of features including rivers, trails, roads, cultural or religious places (e.g. *gumba* (monastery), temples) and school buildings. Therefore, Lego was a quick way of representing quite complex information (Mercer et al., 2010).

5.3.2 Sequence of activities undertaken in the PMEs

The following section describes the activities conducted during the PMEs: (a) selection of communities who would participate; and (b) the individual steps involved in each mapping exercise.

1. Selection of the community for the mapping exercise

Two communities were selected for mapping, Marming , an offn-road location, and Larcha, an onf-road location (shown in Figure 3-1). Both communities were involved in my household survey (detailed in Chapter 4) and participants had shown a good degree of interest in the research, perhaps related to the local relevance of landslide issues, which they had dealt with for a long time. In a typical Nepali mountain settlement, a village or community includes multiple small neighbourhoods called *toles*. In general, a *tole* can be taken as equivalent to a (sub-)community, because multiple households in the same geographical location often share a familiar environment and infrastructure, as well as physical and social resources and aspirations (Mercer et al., 2010; Lee, 2016; Oven et al., 2021), although they tend to have relatively limited socio-cultural diversity. In the context of landslides, *toles* within a small neighbourhood footprint are likely to share common lived experiences of these hazards and risks. Therefore, this exercise was conducted at the *tole* scale, which I broadly define as an area <1 km and/or having <50 households in close proximity. In doing this, my intention was to gain an in-depth insight into community understandings, while also ensuring the inclusive participation of all the people in the community. Therefore, the exercise provided a forum for participation, allowing everyone's voice to be heard (Williams and Dunn, 2003; Andrea and Michael, 2004; Wanasolo, 2012; Jones et al., 2013).

2. Procedure for PMEs

The mapping exercise was conducted in four steps, as described below: building rapport; conducting the mapping exercise; sharing or exchanging ideas; and summarising the discussion. The process was built on protocols widely reported in the literature for similar studies (Mercer et al., 2010; Cadag and Gaillard, 2012; Gaillard et al., 2013; Reichel and Frömming, 2014). The following paragraphs give a brief description of each step.

Step 1: Building rapport and setting up the mapping sessions

The first step was to build rapport and ensure the community's active participation in the exercise. This involved identifying key stakeholders whose support for the research was vital (Mercer et al., 2010). To do this, I approached community members via my existing contacts. I also undertook a more formal approach through the local *gaunpalika* office to obtain permission for my work from municipal or ward authorities, to ensure I adhered to the local formal procedure. Ward officials and elected representatives were consulted, and their help in coordinating the fieldwork in their respective wards was requested.

Wherever possible, the choice of participants for the exercise followed a no bias approach, so that participation was conducted in independent way (Rowe et al., 2004; Covey, 2011). The participants were all regular residents in the same neighbourhood (i.e. *tole* or village), and there was a mix of people including householders, elected representatives, teachers, shopkeepers, homemakers, women's group members and older people. A relatively smaller group of people (4–10) participants was preferred (Table 5-1 and Table 5-2). In such a way, a more focused discussion was possible, and there was more chance of ensuring sufficient time to hear everyone's views, which were then translated into the map (Drew et al., 2003).

The venue for the PME was chosen according to the participants' convenience in their own *tole*, to minimise the walking distance and to ensure that the forum was viewed as a neutral exercise (Saunders et al., 1997; Hussain, 2017). Despite finding a suitable space for everyone to sit during the exercise, finding a time suitable for all participants, particularly as this part of my fieldwork coincided with the season during which intensive farming activities were undertaken, was a challenge. The most convenient time was in the morning, and meetings were generally restricted to approximately one hour. In general, the meetings were confirmed one day ahead; however, it was often the case that they had to be cancelled for a number of reasons: rainfall; local walking trails being blocked; or more immediate and pressing plans for the next day of farming often associated with overnight rainfall. As a result, and in general, the mapping exercises had to be conducted on an ad hoc basis, and in some cases were undertaken at short notice only when a convenient opportunity arose.

Step 2: Conducting the PME

The central activity of the PME was discussion of local landslides and transferring the information generated to the base maps. I describe the process of making the maps and the coordination required in Section 5.3.3. The session included a brief introduction, familiarising participants with the printed base maps to be used for the exercise, which was focused on identifying and locating local features, mapping the landslides and the features exposed to them and then categorising the features associated with perceived landslide hazards and risks. The mapping of landslide hazards and risks followed a four-step process: (a) mapping landslides; (b) locating populations and assets exposed to landslides; (c) assessing the Durham University landslide hazard maps; and (d) comparing different periods. This approach, and in particular the distinction between the hazard and exposure in parts (a) and (b), was undertaken to break down risk into its constituent parts, as per the risk equation (Blaikie et al., 1994). Additionally, the often in-depth accompanying discussion was captured and facilitated by open guiding questions (briefly mentioned in Figure 5-1, Section 5.3.3 and Appendix 1). The discussion was deliberately open-ended in relation to questions about local concerns (Jigyasu, 2002; Wachinger and Renn, 2010), so that participants could share views and ideas in their exploration of local priorities and interests.

(a): Mapping landslides

This step is dedicated to mapping out an inventory of landslides based on participants' recollections (e.g. Figure 5-4). In this step, participants locate landslides on the map by placing a Lego brick. In the first instance, all landslides are marked with a single yellow brick. Once the first level of the inventory has been completed, the next step is to review and characterise the landslides according to the participants' understandings of the risks that each landslide posed. To this end, a discussion about landslide size, movement, threat posed to the village and the damage potential took place. Each of the variables was translated into a relative category of risk. The map in Figure 5-4 is from one of the groups in Chhyadi (Gumba *tole*), and it shows the location of landslides that have been characterised according to participants' placement of Lego bricks.

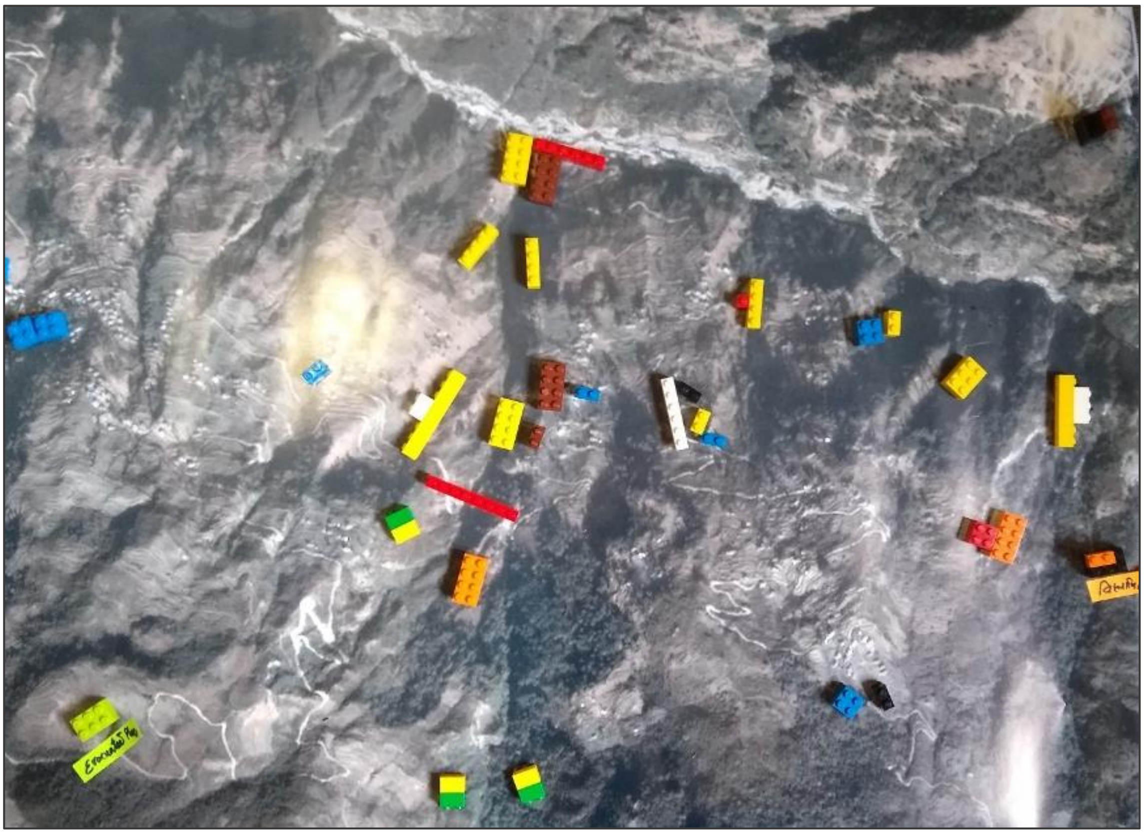


Figure 5-4. Illustration of the use of Lego bricks to show the location and characteristics of landslides identified by participants.

Legend. Orange: landslides in existence before the 2015 Gorkha earthquake; yellow: landslides that appeared after the earthquake; yellow with green top: fast-moving landslides; yellow with white top: slow-moving landslides; red: locations that have become problematic for daily commuting because of blockages; notes with text written in black: origin and displacement; black: destination (e.g. to visit relatives, market centre outside the map area).

b): Mapping exposure to landslides

Once landslides were marked, the next step was to identify those features that faced an apparent threat from landslides in the future (Gaillard and Maceda, 2009). These exposed elements included houses, school buildings, *gumba*, temples, farmland, roads, walking trails, water supplies and electricity poles. Further, participants identified and categorised the exposure of these features according to (a) everyday exposure (e.g. building close to active channels), and (b) more occasional exposure (perhaps infrequently used pathways). This process included making a distinction between, for instance, areas across which children walked each day to school in the monsoon season or areas of concern that had to be crossed less frequently when visiting the local market centre.

(c): Assessing the Durham University landslide hazard maps

In the third step, the landslide maps prepared by Durham University were shown alongside the map drawn by the community. The intention of showing the Durham University map was to assess the participants' opinions of and responses to scientific maps, and to compare and contrast these with their own maps, to evaluate how participants identify the differences between them and appraise the usefulness of each map (Figure 5-5). The results of the PMEs are discussed in Section 5.4.5.

Figure 5-5. Participants working on a Durham University map.

These are the maps used for the second half of the exercise, and are useful in assessing the change in local landslide hazards and risks over time, that is, before and after the earthquake.

(d): Comparison of landslides over time

At the end of the session, I introduced the latest satellite imagery of the area captured after the 2015 GE. The dramatic impact of the earthquake and the coseismic landslides is very evident from the image and provided a valuable means of illustrating the scale of the impact the earthquake has had on the landscape. This process proved exciting for participants in that they realised such changes were visible from space, and they were also able to appreciate how dynamic their own area was. It also proved helpful as a reminder of features that had changed since 2015 (Zhang et al., 2010). Thus, post-earthquake imagery provided the participants with an update on their locality, and also acted as confirmation of the information they had discussed. In addition, this image was useful for assessing how aware the participants were of changes occurring in the valley.

Step 3: Knowledge exchange and feedback

In the final step, the focus was on the participants sharing knowledge and exchanging ideas with regard to landslide hazards and risk (Cadag and Gaillard, 2012). The PMEs used open-ended questions to guide the discussion, and drawing out issues that had arisen during the mapping was useful, particularly in reflecting on questions the communities had, or in raising local issues that often get less attention or are ignored (Sudmeier-Rieux et al., 2013; Oven and Rigg, 2015). In this step, I encouraged participants to raise their questions. Here, I also focused on the potential benefits of mapping, for example, how such PMEs could be helpful in the future for encouraging communication about landslide hazards and risks between communities, local authorities and experts.

Step 4: Discussion, conclusion and Q&A

As the researcher, I led this part of the activity in which I summarised and reviewed what had been done, drawing together the results to form a consensus. Remaining questions or disagreements were also discussed before the session concluded by explaining the next step of the research, and how the outcomes from the PME would contribute to this.

5.3.3 Mapping activities conducted and data collection

The summary of mapping exercises conducted is given in Table 5-1. When possible, discussions were recorded (audio); pictures of the maps were captured with consent, and notes were taken throughout. Audio recordings were first transcribed in Nepali, as the language originally used for the discussion, and then key sections were translated into English. The thematic analysis approach (Lee, 2016; Šakić Trogrlić et al., 2019) was utilised by developing an initial list of codes according to the discussion themes (as detailed in Chapter 3). A five-point open-ended question checklist was used during the mapping exercises and discussions, and this forms the structure for the organisation of results that follows:

1. How do landslides change over time?
2. How do landslide hazards and risks vary spatially?
3. How has the exposure to landslides changed over time?
4. How are landslide hazards and risks being managed at the local level?
5. What the major concerns of local people in terms of future landslide risk reduction in communities?

Table 5-1. List of participatory mapping exercises conducted with two case study communities at neighbourhood or *tole* level in the Upper Bhote Koshi Valley in 2019

SN	Location/ date	Type of community/(*n*)	Other remarks
1	Cheje (25.06.19)	Off-road *tole* (4)	This was the first trial of the mapping exercise, and the chosen venue was the house next to the school in Chhyadi. Four local people participated, including a member of the women's group. See Figure 5-6(1).
2	Chhyadi (28.06.19)	Off-road *tole* (*c*.10)	Conducted inside the *gumba* (monastery), with a mix of male participants living in the Gumba (Cheje) *tole*. One of the largest groups in the PMEs, with ages ranging from 18 to about 50. See Figure 5-6(2).
3	Sarpang (30.06.19)	Off-road *tole* (5)	House yard in a very small *tole* consisting of five people (two males, three females) that is situated below Pokhari, next to a landslide on the way to Saptabal. One of the female participants is the secretary of the *garibi nibaran samuha* (poverty alleviation group), which is a local community-based organisation working at the ward level. See Figure 5-6(3).
4	Larcha (04.07.19)	On-road *tole* (*c*.11)	Conducted in a house next to the *gumba*. Five females, six males. Participants were from households at the roadside as well as the local *tole*. The group included shopkeepers, school management committee members, homemakers and former ward representatives. See Figure 5-6(4).
5	Larcha, near to Fumache (07.07.19)	On-road (1)	Conducted in a house. A brief mapping exercise with a single participant (Netuk Lama, 80y/M), who was a senior person. Four participants from Larcha suggested his views/insights should be taken into account. The house is located in a remote part of Fumache village, next to the hydroelectric power site, so it was impossible for any other participants to join in. See Figure 5-6(5).
6	Lampate (13.07.19)	Off-road *tole* (5)	A house in a *tole* located in Ward 5 (Marming). This was considered one of the *toles* the participatory mapping exercise should definitely include because it was one of the communities recommended for relocation by the Government of Nepal Geohazard Assessment. See Figure 5-6(6).
7	Chhyadi (26.07.19)	Off-road *tole* (*c*.7)	Local shop. A mix of participants, including a local primary school teacher and female members from a *tole* in lower Chhyadi who live just above the Chaku Khola close to a slow-moving (creeping) landslide. See Figure 5-6(7).
8	Marming (27.07.19)	Off-road Group of teachers (4)	Conducted in house offered by the local teacher. One female and three males, all teachers working in different schools in Ward 5, but living in the same neighbourhood. See Figure 5-6(8).

In addition to the above sessions, this part of the study also included other consultations held either individually or in groups, but these did not all necessarily involve mapping directly. These wider opinions and views included those obtained from teachers, elected representatives and *gaunpalika* officers, and they are incorporated into the analysis as a supplement. Table 5-2 lists and describes these consultations.

Table 5-2. List of participants consulted, both individually and in group-based discussions

SN	Location	Type of consultation	Participant(s)	Other remarks
1	Larcha (on-road) (12.10.18)	Individual consultation	Local resident, active *tole* member	A knowledgeable local who is chair of the school management committee in Larcha. The consultation was conducted in his shop.
2	Hindi (on-road) (Oct. 2018)	Individual consultation	Institutional	Interview with the Executive Officer (*gaunpalika* official) at the *gaunpalika* office in Hindi.
3	Khokundole (on-road) (Oct. 2018)	Individual consultation	Elected ward representative	Ward 4, Khokundole, Ward chairperson's office
4	Marming (off-road) (July 2019)	Individual consultation	Elected ward representative	Ward 5, Marming, Ward chairperson, home premises
5	Hindi (on-road) (Nov. 2018)	Group meeting	Villagers	Two group meetings consisting of local villagers. A mix of people, including those who had belonged to former village development committees, and a chair of one of the groups in Hindi.
6	Marming (off-road) (Nov. 2018)	Group meeting	Villagers	Two group meetings close to School dada.
7	Ghunsa (off-road) (23.11.18)	Group meeting	Villagers	Held at a local teacher's house. Six people started the meeting and two more joined in later.
8	Ghunsa (off-road) (09.07.19)	Individual consultation	Active *tole* member	PL, with whom a brief discussion had already been held on 22.06.19. Local knowledgeable person, and other participants recommended his views should be taken into account. He was out of the valley when the main participatory mapping exercises were being conducted.

9	Lampate (off-road) (13.07.19)	Individual consultation	Active *tole* member	CT(70yr/m), local active member of *tole*, who is leading villagers in the relocation process.

5.3.4 Challenges and constraints experienced during the PMEs

In this section, I document some challenges and constraints experienced during the PMEs and reflect upon some logistical and practical difficulties I encountered. The case study communities provide a unique socio-economic context. In general, as a native Nepali, communication with participants was not a major issue for me. However, although all activities were conducted in Nepali, it may have been more beneficial for participants if the conversations had been carried out in the local language (e.g. Sherpa or Tamang) for a more nuanced insight into the internal community dynamics and those issues which the community may or may not want have wanted to share with 'outsiders' such as myself. Given my positionality as an 'outsider' (see Chapter 3), participants might have been hesitant to share the internal 'politics' of the village with me, but a knowledge of the local languages may have enabled me to detect subtle nuances of meaning.

The term 'landslide(s)' is understood by participants in a broad manner. Despite scientific definitions and categories, the community primarily used a more general lexicon with regard to landslides, debris flows and creeping land. Even the distinction between floods and landslides was less clearly made in the mapping. It was evident that sometimes the same term was used in different villages to denote landslides of different types. For example, participants from the Listi community commonly used the term 'landslide' to describe the fast-moving landslides that occurred very close to their villages, whereas in Chhyadi, most participants used the terms 'landslide' and 'debris flow' interchangeably. As a Nepali speaker, I could differentiate between the meaning of local terms used, and I tried to capture the meaning at the beginning of each discussion to avoid any assumptions on my behalf.

The fieldwork for the PMEs was conducted between June and August 2019. Carrying out field-based activities during this season posed two main difficulties: trail or road access to the villages was intermittent; and the villagers' time during a period of intense farming was often limited. One consequence was that the PME sessions were sometimes shorter than I had intended, so the results were not as detailed as I would have liked. In addition, festivals, family rituals and celebrations that take place during the season that starts after Nag Panchami (in the month of *Shravan*, July–August according to the Hindu calendar) and continues to Tihar (in the month of *Kartik*, October–November according to the Hindu calendar) also posed challenges with regard to scheduling, which in many cases led to the postponement of meetings. Consequently, these had to be rearranged, and I had to adjust my plans in line with participants' availability. Ultimately, this also limited the total number of these exercises I could complete.

5.3.5 General observations from the mapping

In the following section, I present two sets of observations from the PMEs: (a) a general description of the PMEs carried out in each of the eight locations (as listed in Table 5-1); and (b) a detailed account of one of the PMEs, showing the stepwise progression towards the final map. In this section, I present a description of the maps, showing how the information generated is collated.

Figure 5-7 is presented sequentially, in the same order that is described in Table 5-1, in which I describe the eight PMEs. The left-hand column shows the mapping exercise in progress, and the right-hand column shows the final output from each exercise.

1. Cheje (25.06.19). Mapping output, using annotated Post-It Notes. Here, the group mainly focused on the areas near to their farmland, identifying potentially threatening landslides.

2. Chhyadi (28.06.19). Mapping output, using Lego for the symbology. Here, the map drawn mainly focused on the Chhyadi Khola, and the potential risks to the village.

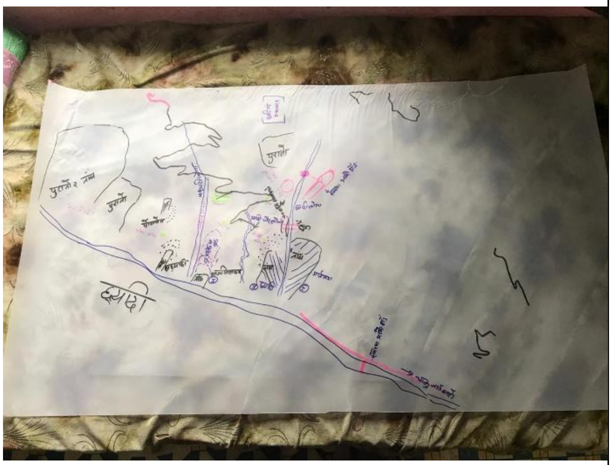

3. Sarpang *tole* (30.06.19). The group mapped mostly between Sangmani and Saptabal, although the area of interest fell partly outside of the base map.


4. Larcha (04.07.19). Here, the focus was on the Bhairav Kunda Khola, and on the Arniko Highway in the main Upper Bhote Koshi Valley.

This exercise consisted of one elderly resident describing his experiences in the context of changing landslide hazards and risks around his village. The exercise also focused on historical accounts that were linked to specific locations on the map.

5. Larcha, near to Fumache (07.07.19). This was an individual exercise with a knowledgeable elderly resident from the area.


6. Lampate (13.07.19). The exercise focused mainly on mapping towards Chaku (north), the local market town in the valley below and on the hillside above (south).

7. Chhyadi (26.07.19). This mapping exercise used tracing paper with no base map. The mapping mostly focused on the main village area, which included an apparently creeping hillslope that was also the area where the most valuable land for farming was located. The mapping also covered the apparent impact of the construction of the local hydroelectric power project.

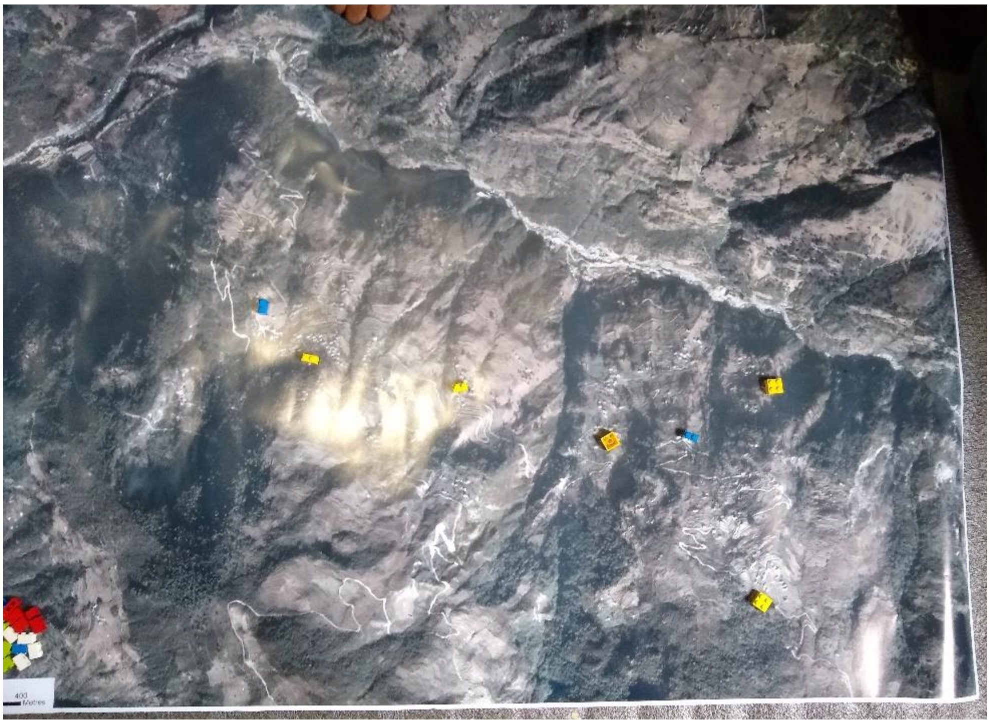
This exercise consisted of a discussion only, because the participants had limited availability. Map references were taken instead of using Post-It Notes and Lego. Talking to this group was important for understanding teachers' perspectives.

8. Marming (27.07.19). During this group exercise, it was not possible to undertake mapping directly, but the teachers involved used the map as a discussion point.

Figure 5-6. Mapping exercises in progress and the resulting output maps described in the same sequential order as in Table 5-1.

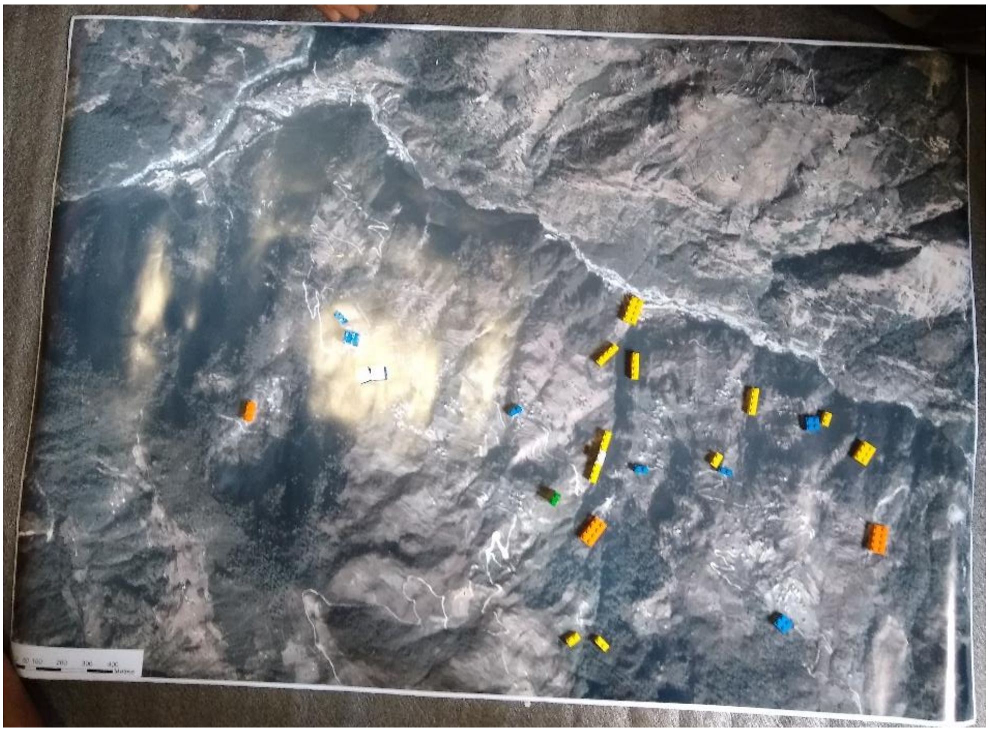
To illustrate the detail of the mapping undertaken in these sessions, one example (Chhyadi exercise (#2)) is described in more detail below. The stepwise process of mapping has been described in earlier sections (and detailed in Appendix 1). As the researcher, I had been to the area several times and was familiar to the participants, so my introduction was brief. This session also included an introduction to each participant. In addition, I took the opportunity to share briefly the initial findings from the household survey to create the background for the present visit. The intended mapping protocol was described, but it was made clear that this could be flexible based on how the session proceeded. I explained that we were interested in collating information on the maps about local issues and geographical features and, critically, information on the hazards and risks posed by landslides, their characterisation and how local features were exposed to them.

Figure 5-7 provides a summary of how one of the PMEs developed iteratively, focusing on three of the five topics that the mapping intended to explore (see Section 5.3.3): how landslides changed over time; how landslides varied spatially; and how the exposure to landslides was distributed, and how this element changed over time.



(a)

The initial step, that is, identifying features of common interest, such as community buildings (blue), and then locating landslides identified by the participants (yellow).



(b)
In the second step, each landslide was discussed and characterised according to the perceived threat and the potential future consequences. Orange: existed before earthquake. Green: origin of landslide.

(c)
The third step refined the detail of the risks understood by the participants and sometimes added more information. Here, landslides are classified by their date of origin.

(d)
The final output map when complete. Here, features considered to be exposed to landslides were added to the map. Dark brown indicates households that are highly exposed and Post-It Notes refer to the displacement of some families after the 2015 earthquake.

Legend. Blue: places of interest, including schools, temples, *gumba* (monastery), etc.; orange: landslides existing before the 2015 Gorkha earthquake; yellow: landslides triggered by the 2015 Gorkha earthquake; yellow with green top: fast-moving landslides; yellow with white top: slow-moving landslides; red: locations that have become problematic for daily commuting because of blockages, particularly in the monsoon; notes with text written in black: origin of landslide; black: site to which villages were relocated.

Figure 5-7. Progression of mapping exercise in Chhyadi with stepwise outputs.

5.3.6 A comparison between 'expert' and participatory maps

Participants' feedback on the different maps used was also noted during the PMEs. Two 'expert' maps were presented to participants and discussed with them: (a) large-format prints of satellite images of the area post-2015 GE taken from Google Earth imagery; and (b) landslide hazard and risk maps created by Durham University as part of the Science for Humanitarian Emergencies and Resilience (SHEAR) project on post-earthquake landslide mapping. The objective was two-fold: (a) to explore how the two expert maps were understood, or not, and to compare the detail on the maps with that collated from the maps generated in the PMEs. As this activity was commonly undertaken towards the end of the PME, the time available was often far shorter than I would have wished. My intention was to obtain participants' views on the usefulness of such data in map form.

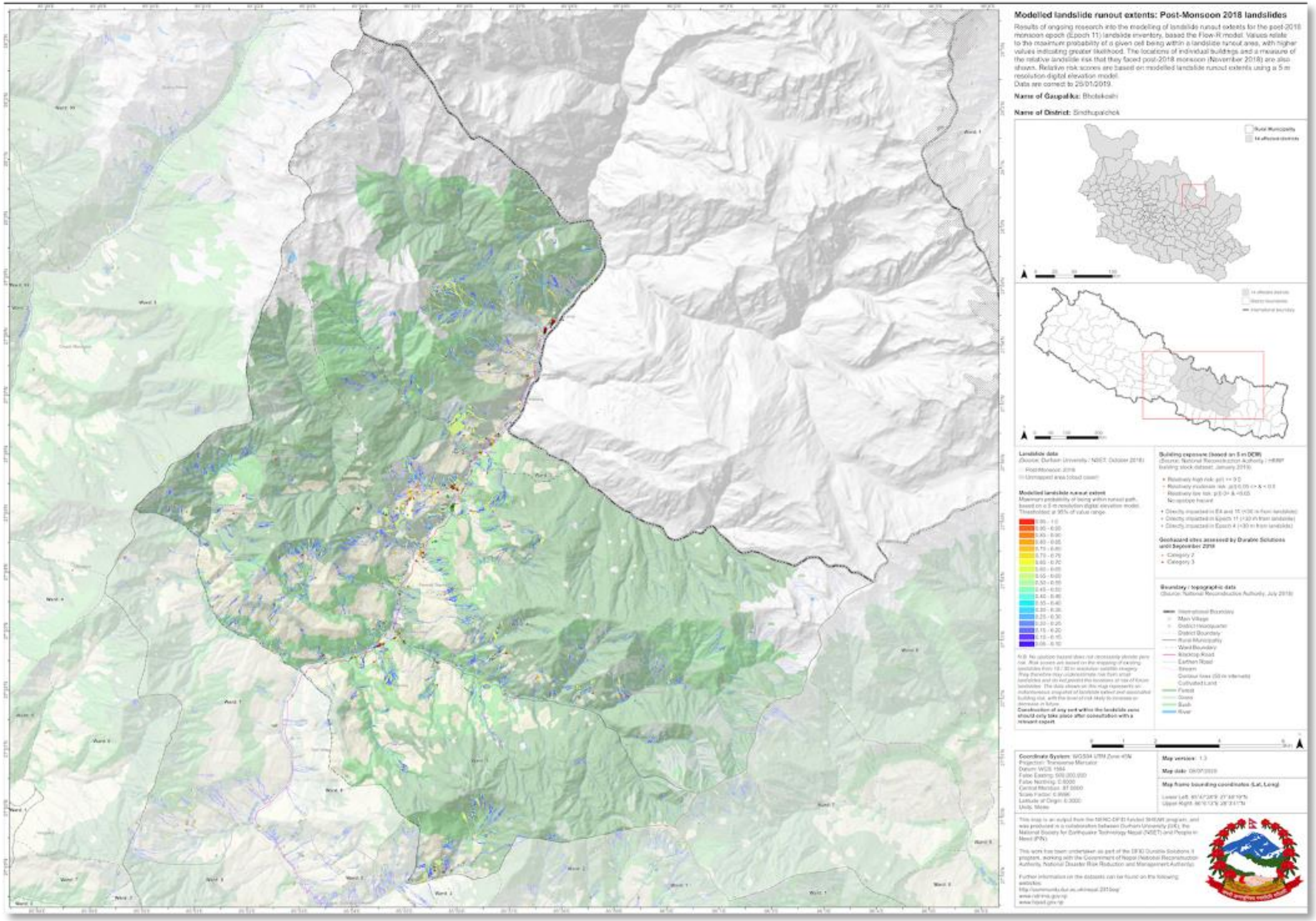


Figure 5-8. Example of one of the Durham University landslide maps for the Bhote Koshi *Gaunpalika*. The Nepali version of the map was used in the exercise.

When considering the Google Earth images of the valley from before and after the 2015 earthquake, the interactions showed that participants were quickly able to orient themselves and to recognise key geographical features. Critically, by comparing the maps, they could identify changes through time, particularly those that had occurred as a result of the earthquake. However, the information on the images was found to be somewhat limited, particularly in relation to the clarity of features and being able to contrast them with others, especially in steep and shadowed areas of the landscape, which are common in the steep valley topography. My impression from this was that if the quality and resolution of the map could be improved, this could significantly increase the engagement with the PMEs, because features could be recognised much more easily. Therefore, it may be useful to explore the use of large-scale imagery such as aerial photos or unmanned aerial vehicle (drone, UAV) imagery as the basis for community mapping.

When discussing the second map, that is, the landslide map prepared by Durham University, the spatial and temporal evolution of landslide hazards and risks was shown at the scale of the whole *gaunpalika*. As a researcher, I was aware of the challenges participants would face in reading a formal cartographic map, given their unfamiliarity with this format of data, and the complexity of the layers of information presented. I explained the legend, the meaning of specific colours (e.g. a time series of change) and other features, to help participants become more confident in reading the map. My initial impression from their feedback was that map reading was difficult for most people, because the majority of participants had never seen such complex maps, and this made the information difficult to interpret. In addition, residents from the locality who had a good knowledge of the area found it difficult to orient themselves with the map right at the start. The problems appeared to be mainly associated with recognising features by which they could locate themselves in the current situation, a process that was relatively quick when looking at the satellite maps. With time, participants were able to comprehend the changing landslide dynamics shown on the map through the changes in size and shape of the mapped landslides, and recognise the areas that were shown to be potentially at future risk from these landslides.

The use of the post-2015 GE satellite image map and the Durham University map demonstrated the importance of enabling access to information from different points in time to show how risks change, particularly in the post-earthquake context. This was found to be very useful for showing how close houses are to landslides or the areas they threaten, and the risk posed to the community. It was challenging to obtain sufficient detail of local issues from maps that actually covered a relatively large geographical area. It would have been much more convenient for participants if the maps had covered only the area of each community, and may have made the process of recognising key local features and specific landslides more straightforward.

I overlaid the three maps created during the PMEs in Chhyadi with the Durham University map for the area, as shown in Figure 5-12. In general, there is a good match between formally mapped landslides and those identified by the community in the area immediately around the settlement. Whereas the data coverage on the Durham University maps was more continuous over a wider area, the locations of more remote landslides were not noted specifically by participants. Although this neither confirms nor refutes an awareness of these more distant events, it does perhaps reinforce a very localised perspective on risks. Given a longer time for the PMEs, it may be that a greater mapped area might have been achieved, and this is something to explore in future works. The PME maps are generally limited to pinpointed locations rather than traced footprints, but they do include some reflection of the inherent value participants place on different locations.

5.3.7 The local *naksha korne* (sketch map)

During one of the PMEs, one of the participants shared a *naksha korne* (sketch map) that he had previously drawn of a large area within the BKGP. This map provides a unique insight into several aspects relevant to my research, especially, as to my knowledge, it was independently produced without training, guidance or outside intervention. As such, the map reflects a snapshot of the participants' geographical knowledge of the surrounding landscape, and also illustrates features that are given priority, for example, place names, landslides and topographical features.

The participant, who was a local government representative in the early 1990s, prepared the *naksha korne* with the intention of visualising local hazards and risks and sharing this information with local people in his village (Figure 5-9(a)). The *naksha korne manche* (person who drew this sketch map) joined the PME, and was keen to share his map. He had always lived above Larcha (between the yellow cross and yellow circle shown in Figure 5-9), and has been an active member of the community, including being the community representative for a period of time. Although the map does not show the date it was drawn, this can be inferred approximately from the detail shown. Based on the features and text shown on the map, it is dated to the early 1990s, and illustrates the extent of the *panchayat* area, a former name for the lowest administrative level of local government, which is now the extent of the wards belonging to the BKGP. Below, I make a series of observations about this *naksha korne*:

- The *naksha korne* details approximately 8 km of the right (western) side of the Bhote Koshi river, from Jhirpu (Hindi) in the south, to Liping and the *miteri pul* (Friendship Bridge, border) in the north. The relative position, order and scale of the features along the road appear complete, and the map has a good geographical precision when compared with a conventional map.

- The map shows exclusively features on one side of the valley (the west wall). This may reflect the political demarcation of this area (the *panchayat* area), and the fact that much of the east wall of the valley here is in China. This delineation may also reflect the area of responsibility for the author of the map during his time as a community leader.
- Originally, the map was drawn on A4 paper, with extensive annotation in Nepali. It also uses basic 'symbols' for features, for example, stippling for forests and hatching for cliffs. The map mentions many place names but also bridges, temples, marketplaces, highways, rivers/streams, forest areas, named mountains, cliffs, ridgelines, etc. Interestingly, the map delineates some key landslides, mostly those in the valley bottom and along the road, which, again, may be a reflection of the area of greatest interest, or the highest number of people and/or risks. As such, the map shows a large amount of detail. One of its particularly striking features is very good accuracy in the representation of the real geography, as indicated by the similar relative positions of the symbols on the *naksha korne* and on the 3D Google Earth rendering of the same area in Figure 5-9(b).
- One interesting observation is the viewpoint of the map, which is drawn as an almost 3D perspective view looking from the east on to the hillside. This appears similar to a perspective someone looking up at the hillsides from the valley bottom would have. However, some areas are more akin to a conventional synoptic cartographic map, particularly in the valley bottom, which again may reflect a common viewpoint looking down into the valley bottom from the valley walls above.
- Interestingly, the space on the map is broken up by key geographical features such as rivers and ridges, leading to the representation of the landscape as being similar to a modern-day slope unit map (e.g. Alvioli et al., 2020).
- Based on the locations marked on the map, it must have been drawn before the 1996 Larcha debris flow (Adhikari and Koshimizu, 2005), which resulted in a significant loss of human life and property. The map does not show the damage or extensive deposits of the Larcha debris flow, but does very clearly mark the Fumache *pahiro* (the landslide above the village), and includes the *deurali* (the ridge location, with a small pass for cattle and pedestrians crossing the ridge), which was the source of the debris flow.
- The map shows a variation in the amount of geographical detail, with a great deal of information along the road and in the valley bottom, and less for the hills and mountains above. In particular, there is relatively little detail between the very high mountain peaks (6,000 m+), and the hills just above the villages in the valley bottom. This may reflect areas that the author of the map was more familiar with, or that were more important to him. Critically, however, this may also mirror a limited awareness of geohazards and risks higher

up in the valleys and catchments above the more densely inhabited area towards the valley bottom.

- The map shows a number of landslides and, in particular, it clearly indicates two large landslides that are still present and active today, illustrating some recognition of the significance of mapping hazards. As such, the *naksha korne* has some parallels with the outputs of the PMEs, showing especially that people have a more detailed knowledge of the area immediately surrounding their location, including what other parts of the landscape may become visible in addition to the area they are already familiar with.

In summary, the opportunity to see what I believe to be quite a rare map, drawn entirely by hand and without external influence, sheds light on how landscapes and the features within the landscape are conceptualised. This is the first example of this type of map that I have encountered in all of my work in rural Nepal, and suggests that similar maps may be quite unusual. Although this is only one example, there are clear parallels with some of the key observations from the household survey and PMEs conducted in this research. The map also perhaps indicates a format that might be useful to explore in future research as a means of drawing out people's understandings of their surroundings and the hazards and risks they face.

Figure 5-9. (a) The *naksha korne* (sketch map) of geographical features presented during the Larcha PME, and (b) a perspective view from Google Earth showing the same geographical extent. Markers are shown on each image to allow the two to be collocated. (Source: Google Earth, 2021).

5.4 Results and interpretation

In the following section, I detail the qualitative results and accompanying observations from the PMEs. In doing so, I first present the results from the PMEs with regard to the spatial and temporal experiences of landslides, as described by participants. Then, I explore and evaluate how participants respond to different forms of mapped information.

5.4.1 Geographical knowledge of the valley, village and surroundings

The first step of a PME is to identify features of interest on the map. This includes rivers and place names, structures such as community buildings, the *gumba* and temple, and key infrastructure such as the water supply, roads and key walking trails. This process was the first means of familiarising participants with the base map, including its scale and extent, and what types of features were typically visible. An example output map from this is shown in Figure 5-10. Although responses varied among participants, generally, their ability to identify most features from the base map was good. At the beginning, participants were most comfortable finding linear features such as rivers or local roads, because these were readily recognisable shapes on the map. At this stage, the exercise aimed to give participants the confidence to understand the landscape on the map, both natural and man-made features.

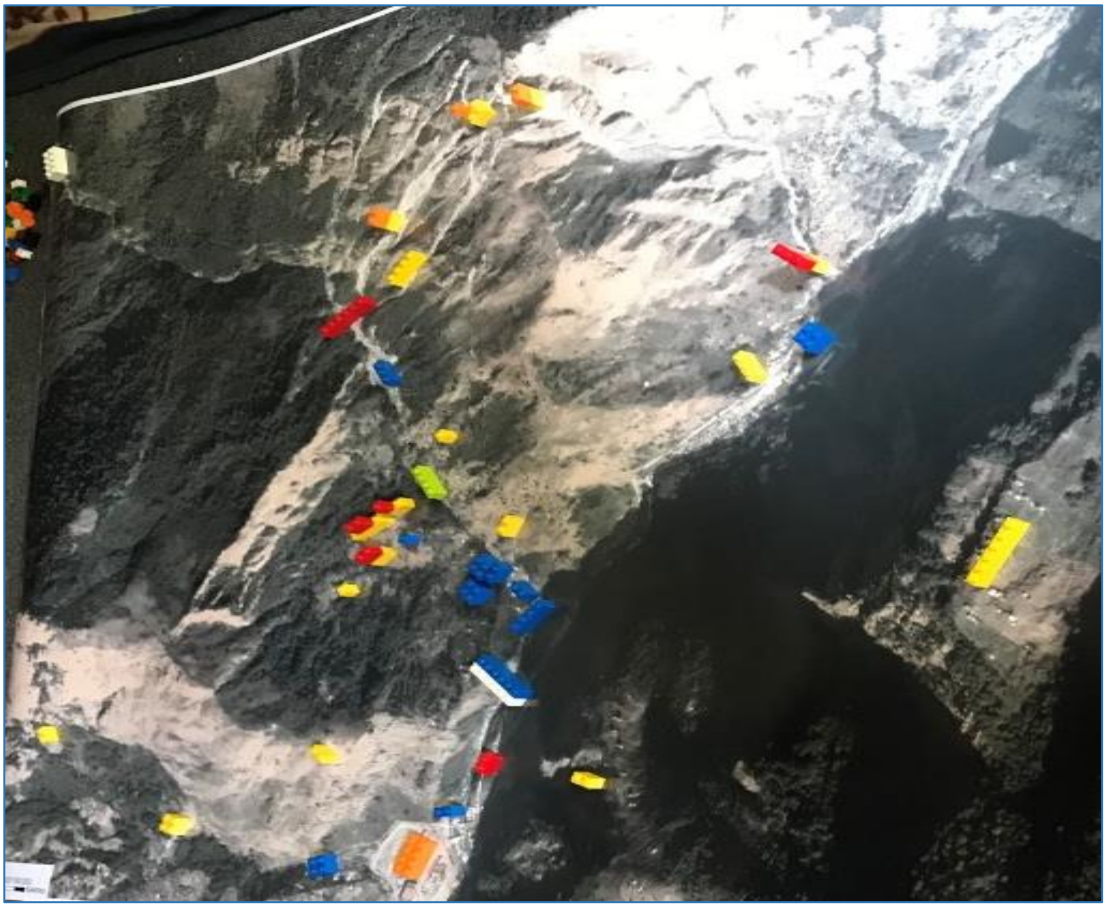


Figure 5-10. Location of community features (in Larcha, on-road) on the map used for the participatory mapping exercise (dated 07.07.2019).

Legend. Blue: places of interest, for example., hydroelectric power projects, bridges, schools and community buildings, *gumba* (monastery); orange: landslides existing before the 2015 Gorkha earthquake; yellow: landslides triggered by the 2015 Gorkha earthquake; red: main threats from or risk areas for landslides.

Some of the participants were quick in identifying recognised features, whereas others needed more time to orient themselves with certain features that were easier to place. Participants in Larcha (Figure 5-10) were able to identify the main river that runs close to their location, the Bhote Koshi, followed by the highway, and then the Bhairav Kunda Khola (stream) that merges with the Bhote Koshi at Larcha. Similarly, in the case of Chhyadi, the wide Chaku Khola was quickly identified, followed by the Chhyadi Khola, and then more local features such as local roads, school buildings, etc. Similarly, during one of the mapping exercises in Chhyadi, the process of debating the locations is described below, which highlights how such features relate to everyday routes and routines:

Q: Can you identify or relate to your location on this map?

The response below:

P1: This Bhote Koshi [river], this PC Office [in Lampate].

P2 This is way to Golchi, the way to forest area [...], this side.

P3 Here, it passes in this way [showing on map]. This one is Chhyadi [village].

In addition, one participant from the same group identified the importance of the date of the image:

Px Okay, are these [showing features and confirming if the map belongs to] before the earthquake?

Similarly, a participant from Larcha recognised the limits of the spatial extent of the map and that the top of the catchment above their own catchment, which includes a locally famous lake, was not shown:

Px: The lake is 'not there' within the map.

The Bhairav Kunda (lake) is a tourist attraction and a religious place, which many from the valley visit, but its location was beyond the extent of the image being used. The lake is also the origin of the Bhairav Kunda Khola, the stream that meets the Bhote Koshi river at Larcha, and that has a significant effect on the landslide and debris flow risk to the settlement.

In the same exercise in Larcha, one of the participants identified changes between the base map and what is now present in the valley, demonstrating an awareness of the recent valley history and how features had changed:

Px This is the river; the dam is here, and the lake should be somewhere here. [Indicating an area off the map, which is the approximate location of the Bhairav Kunda lake.]

P2: This used to be our [Tatopani] VDC office building.

Cross-verification and discussion among participants went on throughout the exercise:

Px It should be a bit further upwards, nearby here.

Then, when I (GK) asked, 'Where is the dam?'

Px *Ya tira, yei ho.* (This side, this one over here.)

Q: (GK) And the powerhouse?

Px: It's here, downwards.

The group exercises illustrated that most participants had a reasonably good geographical knowledge (spatial and temporal) of the location of features in their landscape. Broadly, the larger the ground features, the greater the ability to locate them on the map, perhaps in part related to their visibility. At the beginning, participants tended to start from a broad perspective of the full mapped area, and then narrow down their focus to their own neighbourhood; in this way, they were then able to identify local features precisely. In general, I observed that these features were typically located in the following order: (a) rivers, roads and predominantly linear features, which were prominent and clearly visible in the image; (b) bridges, suspension bridges, powerhouse for the hydroelectric power project, school buildings, dams and larger public buildings, which were all key points of interest; and (c) farmland and its spatial extent and boundaries, and also the respondents' own houses.

5.4.2 Identifying landslides and the risks they pose

The next part of the session focused on participants locating landslides before these were classified into different categories of hazard and risk, based on participants' knowledge of each. An example of an output map from this part of the process (Figure 5-11) illustrates landslides identified near to the participants' community, accompanied with descriptions of each individual landslide event. The size, origin, activity and recurrence, and losses associated with each landslide were discussed. The participants created a final map that included a negotiated categorisation based on these attributes and the associated risks posed by each. The map, shown in Figure 5-12, illustrates distinct landslide groupings with common features and locations.

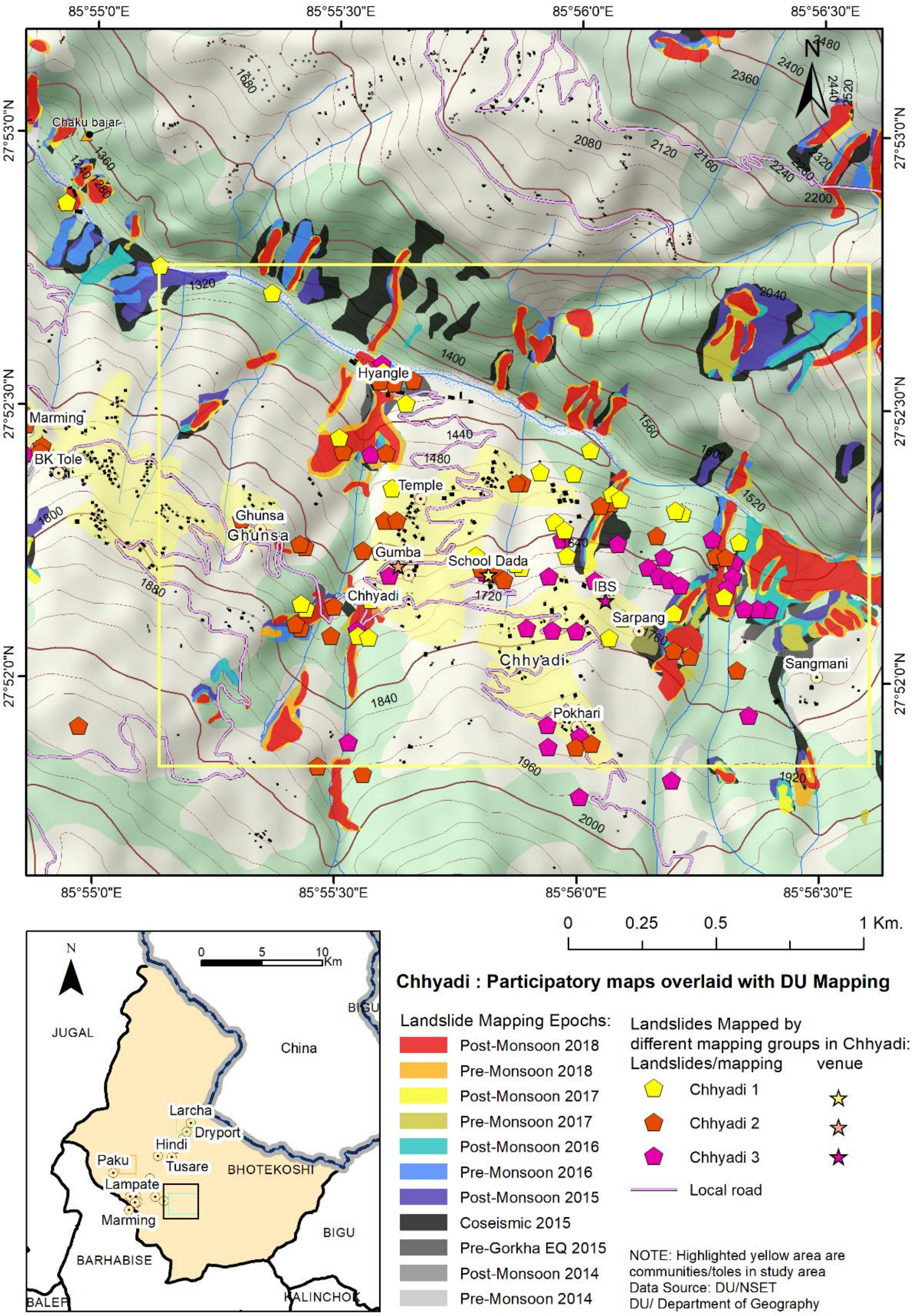


Figure 5-11. Map showing the participatory maps created by three different groups in Chhyadi overlaid with the Durham University expert map. The three different results show some level of overlap and some gaps.

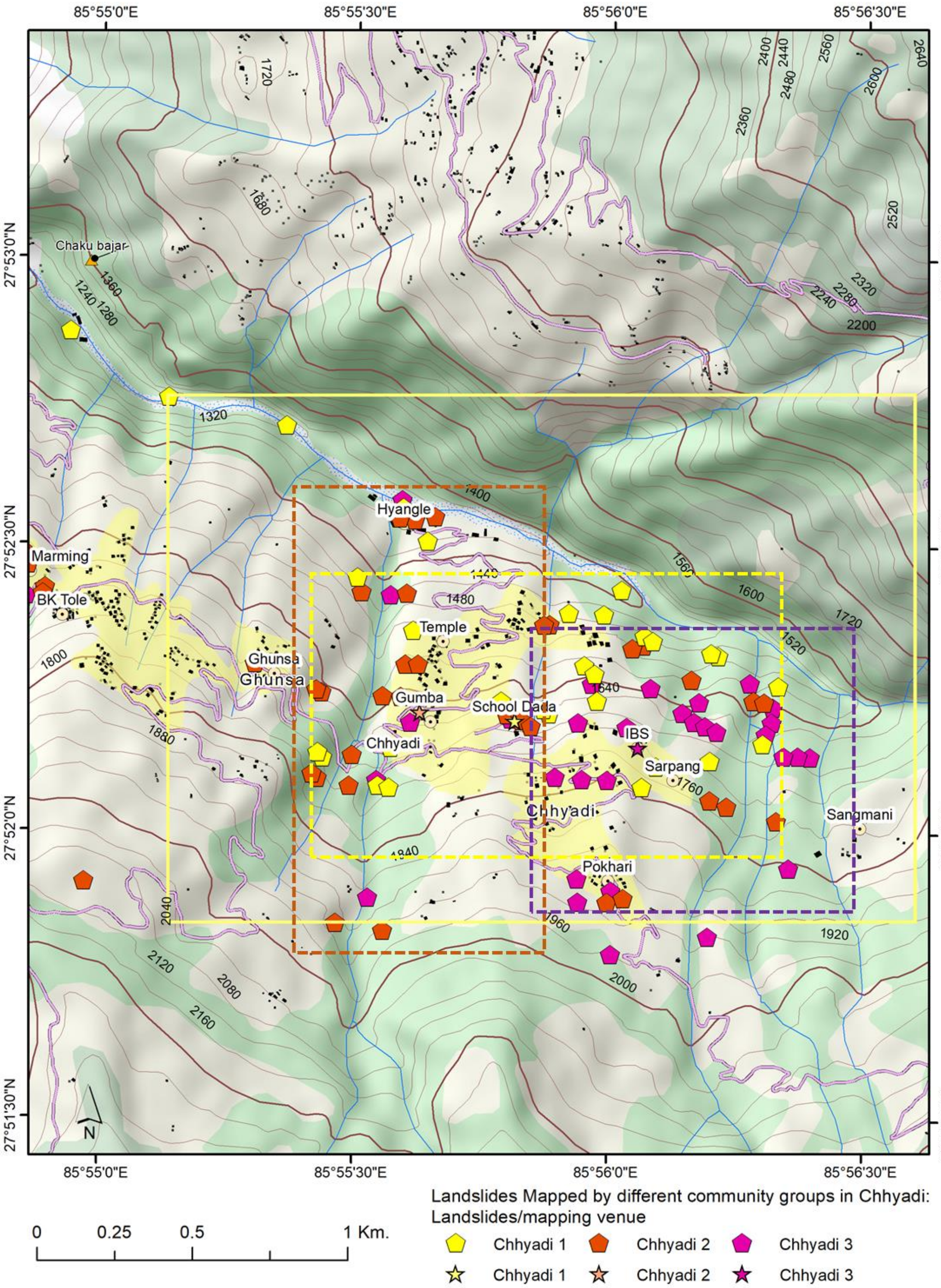


Figure 5-12. Landslides as mapped by three different community groups in Chhyadi, 2019 during separate participatory mapping exercises. The participatory maps have been overlaid by an expert map, showing the clustering of landslides near to each community that took part in the exercise.

Each coloured dotted line box shows the locations mapped by each participant group. The yellow dotted box (Cheje #1) shows more focus on the Chaku Khola, where their farmlands are; the red dotted box (Chhyadi #2) mainly shows the landslides along the Chhyadi Khola; and the purple dotted box (Sarpang #3) shows the clustering of landslide locations between Sarpang and Saptabal.

Participants often recalled quite precisely when a landslide had occurred, for example, a person from one of the Chhyadi groups (Gumba) commented as follows:

Px: Here it is, this landslide existed before the earthquake, this one [showing on map].

Another participant's response gives more detailed knowledge about this particular landslide, which is located just above the village, giving a size, and also a description of its runout direction. The following illustrates how these features were mapped out and discussed:

Px: Landslide, this is a small landslide. This landslide, this one, it has come straight towards up to here [showing on map].

Px: Here it is, here, it has to be one – it has to be here.

Then here [showing on map].

P1: Hyangle.

P2: Ghunsa.

Another participant from Chhyadi (Gumba) commented as follows:

P1: Here it is.

P2: In Ghunsa.

P3: In Saptabal.

Often, knowledge about the impact of the landslide was also recalled:

Px: Hyangle's landslide goes straight to the other side of the river, so it does a lot of damage.

It was observed that participants focused on those landslides, or area of landsliding where multiple landslides existed, that were a major concern based on their potential to directly or indirectly affect householders, a part of the community or the wider area. The mapping also illustrated that most landslides identified were associated with the 2015 GE. In addition, participants noted that many of the landslides had been aggravated by the monsoons following the earthquake. Very few landslides that predated the earthquake were identified, and when they were, they tended to be relatively large in size, well known and of comparatively minimal threat (e.g. Chambang, Chhyadi). Little information on the detail of landslide timing (e.g. at what point during the monsoon the landslide occurred) was captured in the mapping or the discussion.

Although the communities recalled the most recent events in the first instance, later in the exercise, older events, even those from participants' childhoods, often with an approximate year of activation, were identified. These were either assigned to a calendar year or linked to other key events that occurred at the same time (e.g. elections, festivals). For example, in Chhyadi, a participant said that one of the landslides had been there for generations, and also described an awareness of how the landslide had changed over time:

> Px: This is also before the earthquake. Before the quake – [is here since] the time of grandparents, it was [a] small [in area] previously.

Moreover, a member of the group added that the frequency of landslides had changed:

> Px: Several times, landslide happened three times in last year. The year before last year, it happened only once.
>
> Px: Occur every year, happens two to three times a year.

Participants also had an excellent memory for the date of some of the larger landslides, notably those which had resulted in damage:

> Px: It happened on the *Shravan* 19 [the last year, 2018], at which, that day had a public holiday; that in the same night, such a dangerous massive flood in the [Bhote Koshi] river happened. The danger started from that day.

Participants were asked to categorise the landslides according to the causes and trigger factors. One approach they adopted was to group the landslides relative to heavy rainfall and the seasonal conditions, considering this to be a primary trigger factor (e.g. the height of the monsoon between June and September), with another trigger factor being the association with local road construction or the lack of road maintenance. Based on this, participants were of the view that the 2015 GE had had the greatest impact with regard to causing landslides in the valley.

Another aspect that was clear was the lack of differentiation between locations favourable for the occurrence of landslides (e.g. local factors that were conducive to a slope forming a landslide) and the trigger factors that could set a landslide in motion, both of which were mentioned as a single factor during the mapping and discussion . For instance, in the mapping, participants from Chhyadi illustrated the most frequent cause of landslides as being rainfall, but the sensitivity of the landslides to rainfall was believed to have increased after the 2015 GE. At the same time, in Larcha, participants considered the 2015 GE as a primary trigger factor for landslides in the area, but the impact of the event was felt to have outlasted the shaking itself. In several sessions, a reference was made to large rainfall-triggered landslides, notably the 2014 Jure landslide located some 20 km to the south (beyond the extent of the maps). No obvious geographical patterns with regard to trigger factors, or other factors that influenced landslides, for example, geology, were identified by those who took part in the PMEs.

To illustrate the understanding of landslide trigger factors, the following conversation describes how participants perceived the primary trigger factors for landslides, spanning natural, human and development works. In Lampate, a participant said one of the landslides was present but inactive:

Px: It was almost in a dormant stage. When Chilime hydropower tunnel work started, it also begun moving, and again due to the earthquake, it has been increasing [its rate] now.

Similarly, in the Chhyadi PME, a participant said, when pointing at the map:

P7: At the top of Chhyadi Khola, the rainwater from both sides converges and accumulates in one flow and flows downwards. [Thus, it causes landslides and debris flows.]

P8: This landslide above there [showing the village], when the accumulated water drives it to this side [from another side], it becomes extremely speedy when all [materials] mixed.

Hence, in these statements, the participants understood that monsoon rainwater ran into different surface water channels, which then merged and became eroded and, thus, were able to retain a large amount of debris. This load has a direct impact on the channel sides, cutting the river channel and destabilising the surrounding hillside, something that is commonly observed in this valley. Additionally, participants noted the type of materials involved in the landslide, particularly those that turned into rapid and destructive debris flows (e.g. those in the Chhyadi Khola). The mixed materials in these events (termed *dhunga mudha*) are comprised of trees, gravel, muds and soil. Such events are observed in the Chhyadi Khola; here the mix is dominated by mixed gravel and debris. However, in the Chaku Khola, materials tended to be a mix of *khahare* (sand and gravel):

P1: Yes, all mixed. *Khahare,* kind of.

P2: Came like a wave [bark], [along with] all mixed [materials].

Overall, the responses show that people have a reasonably good memory of causes and trigger factors and the materials involved in the process, and were at least able to map out and describe the spatial nature of these processes during the PME.

Participants were also tasked with assessing the hazards and risks caused by landslides. This was done by identifying the most dangerous places (e.g. houses most at risk) in the community, based on participants' understanding of the location of landslides and the areas they threatened. First, landslides that were believed to pose a future risk were identified; then, the locations they threatened were pinpointed. The majority of participants identified the most recent landslides as those events that posed a threat in the near future (Figure 5-13).

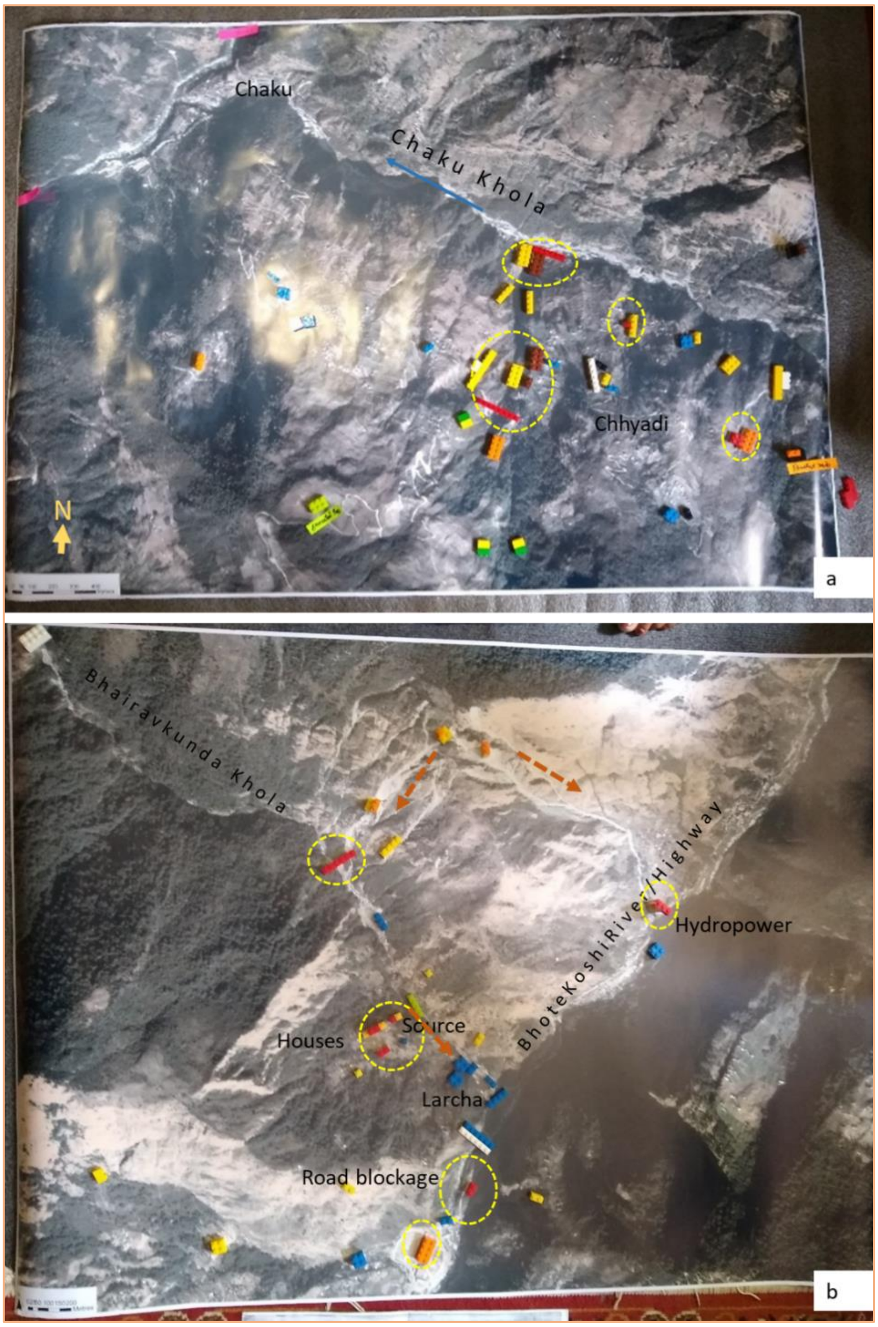


Figure 5-13. Community inventory of landslides and characterisation of each one according to its perceived threat or risk.

Those areas at highest risk are marked with red and dark red Lego bricks, and the surrounding areas of risk are indicated by yellow dotted lines. (a) Mapping of the Chhyadi community, where four locations were recognised as high risk, threatening the everyday life of villagers: Chhyadi Khola (the largest circle); Hyangle (where the Chaku Khola meets the Chhyadi Khola); the problem of slow-moving landslides; and the landslide in between Saptabal and Sangmani that is threatening both communities, (b) mapping of the Larcha community, where four main areas of risk were also identified, two along the Arniko Highway, one at Fumache and the landslide in the main village that is threatening Larcha.

Risk was found to be expressed slightly differently from the identification of landslide locations (hazards), and was also separate from descriptions of the potential to cause damage to a house, farmland or local roads/walking trails (see Figure 5-13, locations in the circled areas are perceived to be the most threatened). The dialogue in the exercises mirrored the mapping. For instance, a resident from Lampate recognised from personal experience the influence of the 2015 GE and monsoon rainfall on the subsequent loss of farmland and livelihoods, either because the farmland was buried under deposits of landslide debris, or because there was disruption to the daily commuting routes to the farmland and other community facilities. Below, one of the participants explains how the community perceives landslide threats, particularly as a result of recent changes associated with an ongoing hydroelectric power project:

Px This landslide located here was almost in a dormant stage, but it reactivated again and started to move when the tunnel construction started. After the earthquake, it has started again and increased land moving in recent years.

Participants in the same group added:

P1: We have risk there, sir [showing on map].

P2: We have risk here [showing on map].

These two views about the location at risk showed recognition of nearby landslide risks. Based on his previous experience, one participant (Ch ca 70 yr/M) added:

Px: It is very uncertain [to predict] when it [the next landslide] will recur, could happen soon or any time [later].

Another participant added:

Px: Don't know when it will happen again, it could happen very soon.

This expression shows the uncertain nature of the timing of landslides, but the situation is countered by the view that landslides pose a persistent risk and that there is the potential for them to be triggered in the future. Risky places, be it the location of the landslide source, or wherever might be affected by landslides, were referred to in quite general terms, perhaps reflecting an underlying uncertainty of where the risk lies within the village, despite very distinct landslide source areas. In Lampate, for example, the link between the landslide source location and where it might travel to was similarly general:

Px: (Ch) It is that above, here [showing on map].

P1: (Cho) This one called Champegang [in Tamang, Champedada, in Nepali, commonly Chambang].

P2: This is the danger that already exists. This one has active [even] before the earthquake [2015 GE].

Px: (Ch) This big one [landslide] has been moving toward this [our village] side.

P2: When it arrives toward us, it has already eaten two houses; that landslide is up there.

Px: Next to these, two houses [showing on map]; a landslide occurred around 8 p.m. on that day. People luckily survived – if it were in the night-time, all people would have been gone.

Participants also shared knowledge of risk in terms of their own location and the timing of an event, predicting future occurrences based on seasonality, or in accordance with major weather events, such as high levels of rainfall in storms. Again, although the date of origin of most landslides was well understood, the frequency or potential timing of reactivation was less well described. For example, participants readily mentioned the year during which a landslide was first observed, but although the overwhelming majority thought there was potential for future activity, when this was likely to occur was highly uncertain:

Px: This landslide started in the same year as the [then] the King [King Birendra] died. (*raja mareko saal ma suru bhayeko*)

Moreover, recalling that the event could happen again:

Px: Yes, and it is continuing since then.

Participants also associated the current risk of landsliding with the ongoing large-scale hydroelectric power development in the valley, for which several discrete geographical locations were mapped out in the exercise. There was less clarity, however, with regard to the underground nature of the development, and its potential to have a perceived impact on slope stability in the valley:

P2: In the year of the king's death, the landslide occurred, stopped for three to four years. When the tunnel construction started, it shook with multiple blasts, so the landslide reactivated again. There is no sign that it is going to stop.

This example was also readily linked to previous material losses associated with the landslide:

Px: No, not the people, the food [grains], water [*anna*, *paani*], utensils, containers, the belongings everything has gone.

However, there was a consensus among the participants that landslides had started recurring more frequently after the 2015 GE and had been more active in monsoon seasons since. Similarly, a participant from Chhyadi (Gumba), identified the risks associated with access:

Px: It's on the other side of the river; here it is [showing on map]. It is on the other side of a river when raining, and it is impossible to cross it (Gy B).

Here, the participants related the impact of the landslides to specific locations (Figure 5-14), which included Hyangle and Chhyadi. Significantly, and perhaps not surprisingly, events that had the potential to block access to the village featured most prominently in the mapping and discussion.

Figure 5-14. Two examples of locations that had suffered the most destruction and were often mentioned by those taking part in the participatory mapping exercises in Chhyadi (Figure 5-10a) as threatening lives and properties. (a) Hyangle, on the way to Chhyadi–Chaku, and (b) landslide on the way to Chhyadi (Marming main village).

Further detail on access was added. This was limited to a few walking trails and roadways, which, if cut off, could isolate the village. These trails were known to be susceptible to flooding and debris flows and commonly experienced disruption:

Px: It obstructs here [showing Hyangle and Chhyadi *pahiro* on the map], via this point forward, we cannot go anywhere (Gy b).

Px: If something happened here [showing on map], landslide, villagers stuck here.

Px: We cannot go anywhere from this place; there is no way to go.

Px: There is no exit from the village, no exit to go to the market, down there [to Chaku].

Px: What if you had to walk around in the rain?

Px: Some places block road trails, roadblocks.

Px: We have a problem in Hyangle [at the bottom of village, confluence of Chhyadi Khola and Chaku Khola], when [Chhyadi] Khola [stream] rises, it blocks the road and Hyangle stops going to Chaku. The road is blocked. The river block road. All debris comes from the above deposited here and again stop the way.

Another observation made was that landslide risk was commonly described as being around the *periphery* of land or property. This may reflect the general location of housing in relatively safe locations often away from the active channels that experienced debris flows. For instance, participants in Chhyadi (Table 5-1, #7) identified a clear concern about landslide risk as it related to rainwater management, and how water already is or could be routed across their landscape, again using the maps to talk through the geography of these occurrences:

Px: The [rain] water collected over road comes down through here and there, just as if you saw here, and flow downwards. The river from both sides comes together [merges], then damages at the bottom.

The same group described in detail the seasonality of rainfall and the effect this has on landslides, also pointing out key differences in landslide behaviour:

Px: This one is slow moving; this one also gradually [showing location, the middle of map c]. This landslide occurs during the rainy season; nothing happens in winter; it appears in the monsoon.

Px: When it rains, it moves below the [surface] ground; thus, the land has deteriorated. Not possible for cultivation, and the land has to be left abandoned [as it is].

The local management of rainwater was quite widely cited in the PMEs as a concern, mainly with reference to where the local road passes through the neighbourhood. In the construction of the new road, previous channels with running water were often disrupted, and replaced with relatively low-quality drainage channels that either failed or became eroded, thus generating further slope instability in the area:

Px: The flow path of water has changed due to the [newly built local] road. Which has increased the risk; it is due to the merging of [new] drainages and natural drains.

Therefore, the association between landslides and the monsoon was clear in all of the PMEs, and the discussion was helped by referring to the maps to describe the nature of these events. Often, a link to historical events in the valley was also made, creating a precedent for what could happen in the future. The oldest participant in Lampate (Ch. Ca. 70y/m) made some observations about the impact of the monsoon on landslides, and this led to his recollection of one of the oldest landslides that occurred in Marming, the village just above his settlement:

Px: (Ch): Yes, when landslide started after the year 2003 [BS according to the Nepali calendar, but AD 1955 according to the Gregorian calendar] it moved slowly and slowly ... then materials taken away slowly, Gumba, Ghyang were moved down and buried. Ghyang, we used to have our space there, so first we moved out from the upper side of the village, moved in different places around, and later finally we came to this place, relocated here.

Subsequently, the community recognised similar threats and the potential for a repeat of this event during each monsoon:

Px: Since the beginning of rain [monsoon], we are afraid this landslide will just run [occur] by now; we feel it will move now. When winter [post-monsoon] begins, this takes a little rest, and then we think this might not happen. When it rains, one should stay alert, sit by window [to stand by to run in case] holding a torch all time.

P2: Take an umbrella and have to rush to run towards the uphill.

Similarly, a participant in Chhyadi described the nature of the local stream during the monsoon:

Px: (GY and others, group): This is the place where Khola became mad [river in spate]. This is the place here [showing on map].

Px: There was nothing before, but now, the river cutting has come up here and stopped now [showing on map] it can be seen. There are trees in this place.

The impact of these changes was noted clearly:

P4: From this side, landslide begins in both sides [of the river]; the debris blocked [river Chaku] from this side by overtopping and jumping to another side of the river at Hyangle, the confluence of Chhyadi and Chaku Khola, then merges.

In this statement, the Hyangle landslide area (on the way to Chaku from Chhyadi via the riverbank) was noted to have experienced multiple episodes of damage from landslides in the recent past that were associated with the monsoon and flooding. This had led to increased concern about the situation in the next monsoon. Throughout, there was a perception that the next monsoon could be devastating. The group also recalled the frequency of debris flows in the Chhyadi Khola and Chaku Khola in previous years that clearly shaped the predicted future risks:

Px: Many times. It happened three times.

Px: Last year, it happened three times. The year before last year, it happened once.

Px: Occur often, happens every year – come two or three times a year.

One of the participants in Chhyadi (Gumba) had a fresh memory of the date when the Chhyadi Khola flooded in 2018:

Px: It happened on the Shravan 19 [the last year, 2018], at which, that day had a public holiday; that in the same night, such a dangerous massive flood in the [Bhote Koshi] river happened. The danger started from that day.

People's recollections of the impact of this event were quite varied but, evidently, the landslide had multiple effects:

Px: (Gy-B) Minor – minors.

Px: Here it is. This is here [showing on map].

Px: (GY-B) It is on the other side of the river; here it is. It is on the other side of a river when raining it is impossible to cross it [showing on map].

Px: It prevents [passing via] here [showing on map] – people [through] here cannot go [pass] anywhere.

Px: If something happened here [showing on map], landslide, villagers [will be] stuck here.

Px: We cannot go anywhere from here. There is no [way] place to go.

Px: There is no place to exit from the village, no exit to go to the market, down there.

Px: We have a problem in Hyangle, when the stream level rises, blocks the road, prevents going Chaku. The stream stops the route by collecting all debris coming from above.

Hence, participants' broad and most typical response was that the monsoon definitely had an effect in that it triggered landslides. However, at the same time, it was also understood that the monsoon had an effect on the physical environment and everyday community life. Again, in Chhyadi (Saptabal):

Px: People who commute from the down, going to *ghatta* [water mill for flour], those in the steep *pahara* [cliff] place, are severe, affecting areas – and Hyangle.

Px: There is no problem once [if able to cross Hyangle] crossed, but before that, there is very difficult, same on the way to Chaku – it has the same [problem] when returning to village [multiple voices].

Px: It is not possible to estimate [predict] or guess when the rock fall will happen [coming] from above [cliff], cannot say when someone could be killed any time on the way. If you see, it's the same case in Sarpang too.

This group identified the key places on the maps that they expected landslides would have the most severe impact on, both within their community and more broadly across the surrounding valley:

Px: It doesn't mean much to us [showing the Sarpang landslide, below Pokhari], but if it erupts there, it will significantly impact the bottom valley areas. It might blow up with debris, [will destroy] first in our settlement nearby, which could cause massive damage to this area [showing on map]. So much damage happened before when the stream was blocked. The flood level reached up to hydro site [a powerhouse building along the Chaku Khola, bottom of Chhyadi village], and damage [due to landslide in Sangmani], originated next to the temple.

Px: If it explodes [meaning sudden], this will cause substantial damage in downstream; it will reach far down up to Khadichaur. While Hyangle will also be swept out. There is possible massive damage in the place nearby [in Sangmani] temple [located some 50 m away from the crown of a landslide below village Sangmani], the possibility of landslides that have always remained in our minds.

Px: If the road disrupted by any event, any way in this site, we might be blocked, here [showing on map].

The participants often reported damage to their individual properties or *tole* due to landslides, and this was a common experience in off-road villages. It often included the impact landslides had on key services such as the water supply, power lines and local access roads. Participants also made links between the nature of the landslides and the damage they caused. There was a common understanding that fast-moving landslides had the potential to destroy a structure (e.g. houses, school buildings, *gumba*, temple or even local roads). On the other hand, slow-moving landslides were considered to have the potential to damage houses or property only slightly, as was the case for families in Hindi. However, in Chhyadi (off-road) and Larcha (on-road), participants often reported that road obstruction was the most challenging problem during the monsoon rainfall, preventing people from accessing the main highway. Conversely, the indirect impact of economic losses associated with the disruption in electricity supply and communications was also reported, but was commented on less often and was not often described with reference to the maps.

One of the mapping outputs that illustrates the potential for local walking trails or roads to become blocked is that shown for Chhyadi (Figure 5-11), where participants identified four bottlenecks that each had the potential to isolate the village from its immediate surroundings in the valley. The Hyangle and Chhyadi landslides intersect the two major outbound trails that connect to Chaku and Marming, as shown in Figure 5-14. Participants used the colour red on the maps to indicate the severity of the associated potential disruption. They also described the previous impact the landslides had had on their daily lives:

> Px: Last year, caused complete damage there [in Hyangle, showing on map]. They [householders] got [some] compensation, [they] get [compensation] in every damage.

Likewise, the impact of another landslide near to Larcha raised concerns about frequent road blockages. Larcha is dependent on the road being open for access out of what is a confined part of the valley, and the village itself is a local market for the nearby villages, especially for those to the east of the river. In Larcha, everyday concerns, especially during the monsoon, were about the lack of maintenance of local roads. This was considered to be a very different risk compared with the highway, which as a strategic road, was maintained by the Department of Roads and so is quickly cleared of any blockages. When the local roads become blocked, residents cannot exchange goods or engage in trade of excess and perishable farm produce, for example, vegetables, especially by sending their goods to Bahrabise, which is situated on the way to Kathmandu:

> P1: For now, the most dangerous section is the highway route for the landslide.
>
> P1: The one [showing on map] here is the most frequent stuck, when going to Tatopani [a local market near to Larcha].
>
> P4: And, over here, we cannot go anywhere from here; there is no place to go.
>
> Px: There is no place to exit from the village, no exit to go to the market town.

Similarly, participants in Gumba (*tole* in Chhyadi) precisely located recurring blockages along their route to Chaku (their local marketplace). They voiced concerns about blockages, particularly in cases in which there is no exit from the village even for emergencies if there is rainfall, and identified multiple blockage locations experienced in the past. The community was also highly dependent on its relationship with Chaku for trade and supplies. However, it was noted that the route between the two settlements had a gentle gradient, making it easier for carrying/portering goods on foot:

> Px: From here [showing on map] cannot way out anywhere. No trails here.
>
> Px: There is no exit from here, neither side we can go, even going marketplace [Chaku].
>
> Px: [These are the] places [of] obstruction, trails blocked.
>
> Px: We have a problem after Hyangle [when] there is rain, flood in Chaku Khola block our way out. It flows souring from above, that obstruct our way out [referring to the route from Chhyadi to Chaku via Hyangle – along the river].
>
> Px: This is the place obstruct several days, and the place the maximum damage.
>
> Px: If there is rain, it will damage over there, and obstruct trail/way out.

In Sarpang (*tole* in Chhyadi) participants had knowledge of the unstable slopes and the common locations of the rock falls, and they expressed concerns about the risk of being hit by rock falls when they walk along trails:

> Px: When you reach the creek down there, you cannot say [very likely] any time might hit by rock falls, coming from above. When a commuter [will] die [kill], cannot say. See by yourself, you have seen, in Sarpang!

This part of the mapping showed a clear understanding of the impact landslides had had on the geography of the area, particularly the problem of surface water drainage, the risk of rock falls on main transport routes and the potential for encountering obstructions on roads and walking trails. Moreover, people identified the origins of landslides, and trigger factors, and discussed the management of rainwater. Therefore, representing participants' observations on the base map and analysing how such information translated into hazards and risks was a fruitful exercise. The process was to some degree successful in teasing out details, and in that it enabled a group whose voices might not otherwise have been heard to discuss landslides. Therefore, the process elicited some new observations that had perhaps been deemed unimportant or tangential to my research, but were critical in understanding the risks people face. The PMEs gave communities an appropriate opportunity to discuss landslide risk, and what this might look like in the future. The exercises also provided a forum in which people could think collectively about the risks posed by landslides, and how these could be mitigated based on previous experience.

5.4.3 Impact of the earthquake

The formal systematic mapping of earthquake-triggered landslides, which covered the 14 districts that were the most severely affected, including the UBK, identified areas in which a high level of landslide activity had taken place and also those where this has persisted in the period since the earthquake (Kincey et al., 2020). This effort involved the preparation of landslide hazard and susceptibility maps, which showed the location of landslides and the areas they threatened, down to individual households. In this section, I describe how community participants recorded the impact of the earthquake on landslides in the UBK.

Unsurprisingly, the impact of the earthquake in terms of landslides was widely recognised by the participants because of its effect on the local landscape, livelihoods, property and beyond. In exploring its impact, I asked the following question:

> Q: What is the difference between these landslides before and after the earthquake? How do you evaluate this? How do you see the difference before and after the earthquake?

Participants described the impact of the 2015 EQ across the UBK. One of the participants in Lampate described his observations along the valley:

> Px: After the earthquake, Bhote Koshi [river] caused a lot of damage. Shaking [cutting] all around, Bhote Koshi's both sides collapsed, everything was taken along away [by river now]. Lots of mass have gone from the part of slopes to the down, in the village.
>
> Px: It almost stopped moving afterwards, [but] when the Chilime hydropower [i.e. Madhya Bhote Koshi] tunnel started to construct it started moving, and again due to the earthquake, it increased.

The experience of one of the participants added a little more detail in relation to which areas had failed and what the consequences were:

> Px: Several landslides occurred after the earthquake. However, there were several already before. The landslide shook this one [too] [showing the one on the slope above his house].
>
> Px: The landslide reactivated after the earthquake, which had stopped for two to three years. It was stable somehow until then.
>
> Px: Large farmland buried in the same landslide [under Marming]. [This referred to the farmland just below the Marming Chambang landslide, which occurred as he remembered in the year 2003 BS, according to the Nepali calendar].

Moreover, participants recalled one of the neighbouring families, who had to evacuate from the village and lost everything, including their land (they became *sukumbasi* (homeless and landless)):

Px: That [pointing to the house] landslide made him [his family] landless. He had no land left behind and buried everything there.

The same group explained the impact on the family, who had to move multiple times in search of a suitable location to live more permanently. This example was common for many householders in the valley:

Px: [The family] went to Tyangthali, where they live now. They do not have any land here, and they just lived here; their parents gave the land to them. The plot is divided between five sons, where three are living in a somewhere different place now.

This illustrates that the earthquake's impact was multi-faceted; it was not just the occurrence, but the potential for a family to lose everything. The triggering of landslides had increased the risk, and forced displacement of householders away from their original home, farmland and neighbourhood that was their only source of livelihood (Figure 5-15).

Figure 5-15. Impact of the earthquake-induced landslides and resultant direct rock falls on a person's house.

(Left) A displaced family's native abandoned house and farmland after the 2015 Gorkha earthquake due to the frequent threat of rock falls (in Fumache, Larcha village); the family has been living elsewhere. (Right) A house in Chaku damaged by landslides after the 2015 Gorkha earthquake. The family was displaced on a permanent basis, because the location of the house leaves it susceptible to further landslide threats.

The scale of the 2015 GE and the impact of landslides from it were such that the effects were felt not only by individual houses, but by whole communities, putting them at risk. Such experiences were related by those who took part in the PMEs in Larcha and Lampate (Figure 5-16) and were related to chronic local landslides.

Figure 5-16. Commonly mentioned representative locations of landslide threats during the participatory mapping exercises.

(Above) Larcha, a local marketplace sitting below the Fumache landslide. (Below) Chambang landslide in Marming just above Lampate village.

Some of the examples mentioned by participants were situations in which communities faced forced displacement due to the dramatically increased levels of risk. One such example was in Larcha, where households were evacuated due to continuing rock falls after 2015. The wider consequences of this evacuation include abandoned farmlands, which have now become barren.

5.4.4 Exposure to landslides

In the PMEs, participants identified features that were exposed to landslides. The discussions about what features were exposed to landslides focused mainly on two aspects: (a) everyday exposure, in which community members or assets were exposed to landslides; and (b) more occasional exposure, for example, individuals being hit by a landslide when travelling. Examples representing such discussions are shown in Figure 5-17, which identifies commonly mentioned locations where people felt exposed to landslides. This section also describes participants' understandings of their exposure to landslides:

> Px: At the beginning of rainfall season [monsoon], this landslide will occur and run at once; we think it will move now [this year]. When winter [post-monsoon] begins, this takes a little rest, and we believe we can stay for the time being. This is happening for a long time and is the situation.

Figure 5-17. Everyday exposure to landslides.

Everyday exposure in often recalled locations during the participatory mapping exercises: (a) route obstructed in the short term due to rain at Chhyadi Khola, preventing people from walking, for example, children to/from school (to Marming main village) – the inconvenience will last a day at the most, usually only a few hours; (b) one of the two exits from Chhyadi village going to

Marming main village; (c) cattle grazing, which cannot be avoided; (d) a rock fall on the major highway could happen at any time.

In addition, more occasional examples of when people felt exposed to landslides included during visits to places outside of the village but still within the valley, for example, unscheduled travel for emergencies during the monsoon, which was felt to be particularly risky. In such a situation, participants described a higher likelihood of encountering obstacles such as rock falls and landslides along the walking trails/roads, and blockages in the river, as shown in Figure 5-17. Conversely, routes used less often, but nonetheless important for visits to specialised health facilities (to Bahrabise or Kathmandu), for visiting distant relatives or to attend festival ceremonies (*chad bad*, *marda parda*, *ghewa chewa*), were very commonly mapped and mentioned by participants as times when they might experience landslides and the associated risks.

Some examples related to getting to and from school, as described below, with family members often considering children to be those most exposed to landslide risks. In one of the PMEs in Lampate, participants expressed worries about the safe return of their children from school in Chaku due to landslides along the way:

Px: Stops, sir, it [showing the location of landslide] block the trail very often in this location. Rock falls often interrupt our movement going to other villages. It is very hard for our children to [be safely] back home from after school, daily. It is very challenging to save [protect] them [from these landslides and rock falls].

Px: It is very frequent blockings; the footpath is in bad condition.

Similarly, everyday fodder and firewood collection (*ghas-daura*) was also deemed a high-risk activity, during which family members had to work close to landslides:

Px: Have to cross the big landslide – the landslide in Jhyalekuna need to travel. There is no trail now but have to cross.

Px: That is right; it is too big.

Q: It does not look so big from the bottom; [but] it is big in the source above, the trail has dug, but it starts moving down again in the rainy season.

Px: This gully [showing its location next to the house where the mapping exercise was conducted], affect us even going for *ghas-daura* [fodder and firewood – there is a daily need for these items].

Px: As you can see below, there is so much mud and stone mix *(dhunga maato*) – that is where it came [originated] from. The [source of] landslide is not visible from below [here, this side, showing on map].

Again, it was observed by participants in reference to the maps that even a very small but high-risk gully has the potential to disrupt the daily commute, preventing travel to even the neighbouring *tole* for basic help. In the participants' view, this could result in the community potentially feeling trapped:

Px: It also stops on the way out; they have to stay on the other side of the hill.

Px: It also stops at grass firewood. This landslide [pointing] belongs to another side. Next to the village, this side.

Px: No farming activities anywhere; whatever we have is here. Everything is here. Everything [livelihood] in Lampate. No alternative property outside Lampate. No single piece out.

Px: It also stops on the way out; they have to stay on the other side of the hill.

From the examples above, both everyday exposure and occasional exposure to landslides clearly have an impact on people's everyday lives in the UBK from an early age, and this continues into adult life when undertaking activities such as visiting the market, visiting other households, going to work and accessing health services. The words used most often to describe such exposure during the mapping exercises were as follows: *ghas-daura* (fodder and firewood collection); *kheti pati* (farmlands); *ban jangal, gai bastu charauna* (jungle for grazing); *bajar* (local market); ward office, school; *swasthya chauki* (health) *and marda parda, bihe bari* (family rituals).

5.4.5 Risk mitigation and reduction

This research focuses on everyday landslide hazards and risks. Participants regularly referred to small-scale landslides that they could manage themselves. Thus, in general, the discussion was focused on means of protection to make an individual's home or property safe using both structural and non-structural measures, often based on traditional mitigation methods where available. For instance, when discussing local risk mitigation practices, a participant in Lampate recalled previous efforts to reduce landslide risk:

Px: To save crops, if the crop grows well, we used to cut drains and control the cut in such land. There used to be such practices; once soils filled the drainage, we used to clean the drainage every year. Sir, villagers used to go uphill and cut it [meaning cleaning and channelling rainwater].

The same participant added that he was unhappy that communities have not continued with such measures. He also recognised that given the size of the landslides, the scale of the landslide risk may now not be manageable with traditional practices, particularly after the 2015 GE:

Ch: Now, [it is] not [practised] in farmlands. Some villagers might have followed if they have farmlands, but they already lost their *khetbari* [farmlands]. I saw in Siyale, they still follow such practices. There is no way of control in large landslides, no idea how it will stop.

The most common practice described in the sessions was the management of rainwater through the use of channels and horizontal culverts that rerouted water towards natural channels. However, respondents in all sessions reported that such practices are now less common, with few examples being identified or added to the maps. Some examples in the UBK, which are in a poor state of repair, are shown in Figure 5-18.

Figure 5-18. Examples of local practices of channelling rainwater, which used to be a common practice and is still continued by some families.

The practice is called making *kuleso* or *bhal katne*, which is a horizontal diversion to the nearest natural flow, mainly towards a local gully; however, these examples look to be in poor condition.

One participant in Chhyadi recommended that some local ideas should be more widely implemented for protecting houses and land from landslides:

Px: We cannot do such a [large mitigation measure] thing, sir. However, if it is small, like ..., if it is like the yard size or smaller could have been managed by household's ability, can be done something. In the village, if it were the work of two or three days, it could be possible [for us as a household], but it occurs every year and becomes beyond [our, household] control. If the government could help [something], we could have done something about these big problems.

P1: It should not be plantation first; make stable by constructing wall-like structures, and once this is a little stable, planting trees would be successful. It can be solved slowly. If you do plantations, it has gone next year, so it needs to make a stable first. That is what I think.

5.4.6 Future aspirations

The PMEs offered the participants an opportunity to discuss their future aspirations in relation to making their village safer and reducing landslide risk. I asked them to describe what they felt would be most effective for a safer future. Initially, the participants were interested in gaining more knowledge, notably with regard to finding out 'what lies beneath the ground' or 'how the landslides will grow' in the future. During one PME in the Chhyadi *tole*, participants' interest was reflected in a desire for more technical knowledge and direct assistance. For example, the community had an expectation that a large boulder (*c*.15 m diameter) that sits next to the village (see pictures, Figure 5-19) should be given a technical assessment. The community was worried and, therefore, eager to hear 'expert views' on the boulder's possible future behaviour and what sort of impact it could have on the village. According to the community, they believed that the boulder could block the Chhyadi Khola, perhaps in the forthcoming monsoon, which might lead to the village being hit with a debris flow. In their view, the only option is to remove or destroy the boulder to minimise this risk.

The participants also noted the potential hazard from creeping slopes in the Chhyadi *pahiro*, which, again, could block the river flow and increase the potential for future debris flows. Furthermore, participants expected input from outside 'experts' to give them reliable information on how the risk can be mitigated:

Px: As I believe, you are well-educated person, people like engineers, you also know people from abroad, you all know them, technicians, [so] we may request you to link our problem to them, and to higher authorities, *gaunpalika*, and link us if they can do something technical for us! That is to say; we would be pleased.

(Source: purenepal facebook @nepalmustdo. Published with permission).

Figure 5-19. One of the places in Chhyadi village that was often cited as a risk area during the participatory mapping exercises. Those who took part expected external technical and other help to manage the removal of a large boulder.

The figure shows three hazard sources meeting at one point, increasing locals' concerns about the entire village as well as the houses at Hyangle below in the valley along the Chaku Khola.

Figure 5-19 shows the area at risk, and the location of the boulder the community is seeking to remove. At the same time, the slow-moving landslide on the right bank of the river underneath the houses also presented a risk in relation to blocking the Chhyadi channel at this point. The community believed that these two things combined could act to collect a large volume of debris that could bury the village. Again, the community believed that the *gaunpalika* office has no ability to provide a technical perspective, and so options for assistance from within the valley were believed to be limited.

5.5 Discussion

In this section, I discuss the geography of community understandings of landslide hazards and risks based on the findings from the PMEs. The exercises illustrated how to link spatial information and temporal changes by employing maps, which were then used as a basis for discussion. The aim of the process was to enhance community understandings of landslide hazards and risks. In addition, it offered active individual and community engagement by providing a forum for discussion, and helped to show participants what their own potential role in risk reduction could be (Aye et al., 2016; Haworth et al., 2016).

5.5.1 Key methodological observations and achievements

The PMEs were developed using the lessons learned from earlier studies that used participatory mapping techniques for exchanging knowledge and ideas between experts and people in a community (Rambaldi, 2010; Gaillard and Mercer, 2012; Gaillard et al., 2013). In using PMEs, this study has gained a significant insight into landslide hazards and risks. I have summarised the lessons learned from my own use of PMEs below and assess the effectiveness of the approach on three counts: (a) as a means of assessing community understandings in the socio-economic conditions of Nepal's middle hills rural context; (b) as a means of exploring informal risk assessment for landslides in Nepal; and (c) as a forum in which to discuss risk management strategies for the future. In the following sections, I reflect on these lessons and the challenges faced:

1. The true-colour Google Earth images were a good resource for conducting the PMEs because the community quickly grasped and visualised their landscape, which meant that the exercise moved forward at a good pace.
2. The PMEs provided a well-structured forum for identifying, sharing and assessing local hazards and risks with a wide range of participants. Moreover, they offered participants a dynamic way of discussing local issues (Gaillard et al., 2013; Rambaldi, 2010), thereby enabling them to move towards a consensus viewpoint. Throughout the exercise, participants reflected on their individual and shared knowledge and insights.
3. The PMEs followed a locally adaptable protocol based on similar earlier experiences elsewhere (Wagner, 2007; Haynes et al., 2008; Mercer et al., 2008; Gaillard et al., 2013; Klonner et al., 2018). The stepwise procedure that was developed proved satisfactory in providing sufficient time for participants to formulate their initial opinions and then revise them.

4. Lego was a useful visual tool for showing the characteristics of features that were added to the maps. Although this study did not intend to assess the use of Lego as compared with other techniques, it proved to be successful in displaying and visualising features, and had an added advantage in that the size and colour could be altered, so the features it was representing could easily be modified when a consensus was reached. This meant that participants with no previous experience of mapping were able to engage in the activity. The Lego was also easily identifiable in photographs of the output maps, as shown above.
5. The challenges were various. One of the main ones was that I tried to use exactly the same approach in the different villages, but found that a more flexible way of working was what was required, tailored to each group's participation in the exercise. The participants were always different, and so the direction the discussion followed also varied. A major challenge was trying to hear everyone's voice, particularly when a minority tended to dominate proceedings.

5.5.2 Community understandings of landslide hazards and risks

The PMEs and associated group discussions brought together different local issues and both spatial and temporal information, and resulted in knowledge exchange between the researcher and the participants (Cadag and Gaillard, 2012; Haworth et al., 2016). A mixed-methods approach using open-ended questions tailored to exploring local issues (Saunders et al., 1997; Crang, 2007) was found to be both feasible and practical to implement, and appeared effective as a means of stimulating discussion about landslide hazards and risks. In analysing the maps and quotations, the information generated could be triangulated.

The output maps generated from the PMEs have the potential to address the gaps in conventional landslide records, which do not usually provide detailed information for individual local landslides and, in particular, do not prioritise those which are of greatest concern to the community (Hernández-Moreno and Alcántara-Ayala, 2017; Samodra et al., 2018). It was clear from this research that in using PMEs to collate detailed locational information that the community holds, albeit in a non-systemic manner, it would probably be possible to provide some of the missing essential information needed for planning at the local level. A landslide map drawn by the participants that included the perceived size of landslides along with information about their characteristics they felt to be important, offered a clear view of past events, which can be used to consider future threats (Galli et al., 2008). The PMEs also demonstrated the potential for combining information gained from remote sensing or freely available satellite images (Goodchild, 2008), which is often produced without adequate knowledge of local conditions, with other sources of information, including expert maps and local knowledge (Klonner et al., 2016; Samodra et al., 2018). This is potentially critical for creating an accurate and complete account of hazards and risks at the community level in Nepal, such accounts being rarely available to date. In such a context, the research in this study has suggested that a bottom-up approach to the production of landslide mapping and risk assessment, creating a local hazard map with local communities based on their own interpretation of first-hand observations and experience, is very valuable and effective.

A further benefit of generating landslide inventories locally in this manner is the inclusion of more local landslide locations that are otherwise missed by the quite crude and often impact-based inventories that describe landslide risk on a national, regional or global scale (DesInventar Nepal, 2017; Froude and Petley, 2018; BIPAD Portal, 2021). Such conventional approaches often have limits in terms of resolution, and do not readily include landslides that have not yet had an impact, or those that are too small to be visible on satellite imagery (Chae et al., 2017; Dikshit et al., 2020). PMEs can also add clarity with regard to the timing of landslides, which is essential where remote sensing is ineffective during the main landslide period in the monsoon due to cloud cover (Williams et al., 2018). In addition, PMEs demonstrate that the community inventory produces an often more nuanced understanding of each landslide. Conversely, it is evident from the PMEs conducted here that community mapping is most commonly limited to what is known or visible, and so may overlook distant landslides either up or downhill, despite these still having the potential to pose a threat. As a result, there will inevitably be discrepancies between landslides mapped locally and those mapped using more scientific techniques.

When comparing the two output maps prepared by the Chhyadi (Gumba *tole*) and Sangmani groups, the maps show a concentration of landslides specific to each *tole* (shown in Figure 5-12), even though these two areas are only *c*.500 m apart and share the same social and physical infrastructure. This perhaps surprisingly localised focus illustrates that community concerns are concentrated on an individual's local and daily needs. Additionally, participants are primarily concerned with their own neighbourhood location and are most aware of hazards in close proximity to their own settlement. Such a view was commonly related to direct previous disaster experience (Klonner et al., 2018), and reflects a wider common engagement with hazards close to where people live (Zhang et al., 2010).

The use of Google Earth images, or any comparable high-resolution satellite imagery readily available in the public domain, was found to be highly beneficial for this research. One constraint was that the imagery had a limited capacity for identifying small features and another was that it had to be recently captured. Both of these were found to be significant in enabling participants to identify features such as landslides (Williams et al., 2018). This was particularly important for participants unused to looking at maps and satellite images; better data allowed easier orientation with features on the ground. Although increasingly easily available, the limits of such images in terms of resolution, extent and timing persist, inhibiting the identification of both smaller or older landslide events (Tian et al., 2020). The more locally detailed information captured by placing Lego on the maps allowed the relatively accurate positioning of features alongside other forms of geo-referenced information (Haynes et al., 2007; Gaillard and Maceda, 2009; Reichel and Frömming, 2014; Samodra et al., 2018).

The scale of the maps used in the PMEs (A0 size, covering approximately 4 x 2.5 km of the UBK) was chosen to enable the identification of places of interest. Despite the ease of producing such images and the relatively good resolution, challenges remained in relation to occlusion and shadowing in the steep topography, particularly in the areas around the confines of the steep valley bottom. The difficulties experienced during the PMEs could have been addressed with a more extensive discussion about perspective (on the ground) photographs (Haynes et al., 2007), or perhaps UAV footage, allowing participants to relate the imagery more closely to their own perspective of the landscape. In addition, this study was limited to readily visible landslide features and so did not consider any sub-surface or ground characteristics, for example, soil or rock type, when mapping. Further, small-scale features such as cracks, or even landslides that have not fully broken through the ground surface cover, are also impossible to see in the imagery; therefore, interpretation is subjective and largely based on local experiences only (Rambaldi, 2010). Incorporating such information into the mapping exercises and associated discussion could have been more informative and insightful, especially when discussing the role of causative factors of landslides or internal–external ground relations, and how these have evolved over time (Jaboyedoff et al., 2016, p. 218).

The representation of landslides during the mapping exercise was achieved using different sized Lego bricks. For instance, in Chhyadi, all groups marked two particular landslides as the most dangerous: one on the way to Marming village located between Chhyadi and Ghunsa (*toles*), and another at Hyangle, located between Chhyadi and Chaku along the riverbank, shown in Figure 5-14. These two locations were given the highest priority, as indicated by the colour red, and the largest brick was chosen to show the significant perceived level of danger these landslides were understood to pose to the communities. In addition to their risk, these two landslides were also noted for their continuous recurrence in every monsoon, or even after any single heavy rain event during the monsoon, causing potential destruction to the areas along the sides of the riverbank (see Figure 5-14, at Hyangle). The similarities in these two assessments suggested that the strong or weak representation of participants' priorities is a measure of the perceived threat faced, based on previous experience of damage and proximity to the hazard (Wachinger and Renn, 2010; Zhang et al., 2010; Lujala et al., 2015). The distribution of landslides mapped by communities, which was limited to quite a small geographical area around their settlement, further suggests that people are concerned with their own local communities or surroundings, or in other words, as earlier argued, with everyday problems in the immediate neighbourhood.

a) Mapping exposure to landslides

Exposure to landslides in the hill and mountain areas of Nepal can arise from settlement in areas that frequently experience landslides or landslide runout, which significantly increases the risks to people and property (Hovius et al., 1997; Petley et al., 2007; Crozier and Glade, 2012; Vuillez et al., 2018). When considering risk reduction measures, mapping out exposure to such risks is essential. The PMEs undertaken in this study suggest that participants have a good understanding of the threats to their settlements (*toles*), but these views were commonly focused on the biggest landslides people were aware of. In continued discussions, particularly with those householders who lived close to landslide locations, not surprisingly, people had a heightened level of awareness and were more concerned about the potential for their property to be destroyed. An overarching observation was that there was uncertainty about when land would be lost, and how individual landslides could change in the future. In general, the PMEs showed that participants were more than able to identify some families (houses) located in areas they considered to be highly exposed (e.g. Sangmani and Larcha, both particularly at risk since the 2015 GE). For example, in Larcha, the entire village was deemed exposed to landslides from both upstream and the surrounding hillsides above. Similarly, in Chhyadi, participants recognised that they were exposed to landslides of various sizes and styles that occur all around the village. This heightened awareness perhaps reflects the daily interactions people in this community have with unstable areas, along with the relatively high visibility of unstable slopes in the surrounding landscape.

Exposure to landslide risk was expressed in terms of both the place where people lived, and the routes along which they have to travel (Lee, 2009). Hence, the community exposure to landslides was understood in terms of space (e.g. related to people's houses and property) and time (e.g. when people had to pass through an area of landslides). This second expression of exposure related to visiting grazing cattle and farmland, going to work or visiting the local market or relatives. For example, a family in Larcha, who were forced to evacuate from their original village, have to return to the original village location, which is deemed to be at very high risk from landslides, to tend to their goats and land. The family worries about the trip every day, because they have to cross multiple large landslides. Such examples of essentially unavoidable or voluntary exposure, which inevitably has a very seasonal nature, are commonplace, and were a constant feature that emerged from the PMEs. This observation was similar to the findings of Alexander (1991) and Wachinger and Renn (2010), who explored examples in which choices available were often defined by what was affordable when avoiding or minimising exposure to risks. For example, in a PME in Lampate, the group articulated their own very limited choices, because all of their property lay within a high-risk area. In addition, their own limited skills, which restricted their livelihood options, meant they had little choice other than to stay put.

‘Landslide exposure requires knowledge of how landslide hazard varies in space’ (Milledge et al., 2019, p. 837); therefore, logically, this sits alongside recognising where safe(r) areas are located. The maps created during the PMEs have the potential to be used as planning tools in that they provide useful information for zoning, or planning for risk-sensitive land use and infrastructure. As such, communities can play a role in the risk management process (Alexander, 1991; Fell et al., 2008; Paton et al., 2008), for example, by identifying routes for evacuation to safe havens, or prioritising local mitigation measures. Despite demonstrating a good knowledge of exposure to active landslides, communities often have limited choice and live in relatively high-risk locations where landslides are just one consideration (Oven, 2009). For example, the Saptabal *tole* in Chhyadi is in a location where landslides pose a threat, but despite knowing their potential exposure, the community cannot afford the costs associated with relocation. The PMEs can be considered to be a consultation process during which voluntary actions that would assist risk management can be identified (Beider, 2018). In addition, purchasing a new plot of land has become more difficult for householders; this became a critical factor particularly after the earthquake. Costs have increased, and finding a safe alternative in surroundings that can also support a livelihood has been challenging because of a lack of available land, although this can be achieved with the support of an extended family (*daju bhai*) (personal communication with GY). Hence, the root causes of a community’s exposure also depend on its own inherent vulnerability, and its capacities in relation to income, security of its livelihood, the engagement of individual families with the community and the skills people possess to overcome disruption after the earthquake. Inevitably, the most vulnerable families are some of the most badly affected, and the 2015 GE is viewed widely as something that has caused such families to take several steps backwards (Tamang, 2020) because their lack of resources limits the choices they can make to minimise the landslide risks they face. For example, a Chhetri family in Tatopani, who have had to relocate several times during the last decade, had to leave their current home and find a new site because of the loss of their farmland. Their new location is close to a gully, which presents different risks because it is potentially susceptible to debris flows from above. A further distinction made in the PMEs was in relation to a household’s wealth. In Chhyadi, a women participant said,, as mentioned earlier ‘rich people have their house in Kathmandu, but we have nothing other than here, have to live here at any cost’, again reflecting limited choices for many. However, the PMEs suggest that not all houses in the community were at risk from a landslide, similar to the findings of Oven et al. (2021) and Tamang (2020); therefore, it is important to bear in mind that not everybody is equally at risk.

When the PMEs moved on to discussing what to do about landslide risks, the view of the participants, particularly in Chhyadi and Larcha, was that the mapping alone was insufficient, and their expectation was that an expert level of assessment was what was required next to work out how to reduce risks. However, although I was clear about the intention of my research objectives and the limits I had imposed, the relative weightings assigned by participants to areas of concern may have reflected their presumption that some support would be available as a result of their prioritising those landslides that were of most concern. Be that as it may, I was aware of the potential vested interest (Pilgrim, 1999; Yi Chiu Ka and Eidsvig, 2016) and was very clear throughout that this would not be the case. However, in undertaking the PMEs, the participants showed a real interest in how to predict future risks better, and sought confirmation as to whether a place could be deemed safe.

The PMEs also produced detail about the timing of landslide hazards and risks, and seasonal exposure, notably in terms of participants' seasonal experiences. The monsoon has been the most challenging time for the community, especially when walking to locations a long way from the village. Because the community assigned relative weightings to risky areas using Lego, the categorisation illustrated their own qualitative evaluation of risk, as reflected by the discussion. At no point in the discussion did an alternative or better source of information come to light, such as a landslide hazard map produced by the *gaunpalika*, a land use plan or any guidelines as to how communities should manage the landslide risks they face. This, combined with the participants' abilities to assess their own environment, implies that there is a knowledge gap between communities, and planning and risk management, because current policies and practices do not meet the needs of local people despite their interest and awareness of the hazard and risk issues (Antronico et al., 2017).

b) Landslide risk reduction, disaster risk management and governance

At the household level, risk reduction measures for protecting their own property commonly identified by the participants included the construction of masonry walls and local repairs, for example, to terraces. However, these efforts were not often described during the PMEs, and although the participants reported the extensive nature of landslides across their surroundings, these were deemed to be beyond their control or capacity to address because of their scale and dynamic character. In the context of such extensive landslides, it was evident from the discussions that the communities believe their management requires comprehensive technical guidance from the relevant government agencies, who could and should provide technical and financial support.

Like Sudmeier-Rieux et al. (2019) and McAdoo et al. (2018), one of the notable findings was that the communities perceived high losses associated with the landslides triggered by the 2015 GE, and that these continue to have a negative impact on every household. This was felt in the permanent loss of farmland and the need for reconstruction, which is often a challenge because the landscape is still in a fragile state. The delay in reconstruction, which is associated with the bureaucracy of government financing, has also meant that decisions were made sometimes months or even years after the earthquake, so the communities have often had to remain longer in areas that have a high risk of landslides (PL/ c. 50y/m, Ghunsa/personal communication). The least affluent families have also been disproportionally affected, and this has been attributed to the lack of a diversified livelihood support system or network (Pilgrim, 1999; Sudmeier-Rieux et al., 2013). For instance, a common response from villagers was that more affluent residents could temporarily or permanently migrate to Kathmandu and pay the cost of either repairing their house or relocating to a safer and more sustainable location. Conversely, the less affluent had no choice but to compromise safety because of the high costs associated with alternative courses of action and decision-making (Pilgrim, 1999; Tamang, 2020).

Community expectations of local government in relation to reconstruction were often mentioned during the PMEs, in addition to complaints about a lack of support for landslide risk reduction. Participants complained that local authorities (*gaunpalika* level) have not been concerned about these issues, and that responsibility had been passed on to federal bodies, for example, the NRA. Communities were often faced with needing both technical and financial support, but in the main this was not forthcoming; therefore, they were left with no choice but to reconstruct their houses without any expert assessment, for example, with regard to the ground conditions, except in a relatively few cases when standards were stipulated by the NRA GHA. Acting on this report relied on the identification of high-risk areas by the *gaunpalika* officials, so if this was not done, the assessment was never conducted.

In terms of local planning, however, the local *gaunpalika* has the authority to allocate funds from its annual budget for disaster risk management. In relation to this, most participants identified a need for a better focus on the places identified in the PMEs, and a more effective use of financial resources for dealing with landslides that threatened the community. Comments with regard to the local budget allocation were concerned with (in)appropriate use of resources, fair allocation and a way for communities to have their voice heard within this allocation. In addition, it was felt there was a need for technical assessment of landslides of concern to ascertain whether mitigation was viable. It was also thought that any suggestions as to how communities could improve safety would be very valuable.

Participants held a common view that the larger landslides will pose a higher risk in the area. This could have been related to direct experience of large landslides in the valley, something that is often discussed among villagers (e.g. the 2014 Jure landslide). The weighting assigned to hazards and risks noted in the PMEs is aligned with the influence a familiar and relatively well-understood system – event size, proximity and familiarity – has on risk perception (Lupton, 1999; Slovic and Weber, 2002; Wagner, 2007; Wachinger and Renn, 2010; Zhang et al., 2010).

Extensive development works in Nepal, such as extensive rural road construction and hydroelectric power projects, which can be adjacent to communities, are often linked to landsliding (Petley et al., 2007; Devkota et al., 2014; Oven and Rigg, 2015; Sudmeier-Rieux et al., 2019). The degree to which these are directly attributable causes of landsliding, or purely coincidental with the occurrence of landslides, remains unclear, but there is little doubt that their effects have been exaggerated by the 2015 GE. The participants were very much aware of the changes that had occurred since 2015, commenting on the fragility of the landscape and how this interacted with the other ongoing changes. Thus, the community certainly expect future significant landslide hazards, and directly attribute these to development activities.

5.5.3 Landslide hazards and risks through time

In the sections above, local understandings of the spatial dimensions of landslide hazards and risks were explored using PMEs. These understandings of landslide threats included both knowledge about the location (where?) and event size (how large?), and about the temporal dimensions such as the frequency (how often?) and timing (when?) (Crozier and Glade, 2012; Knevels et al., 2020). The main challenge is the temporal dimension of risk with regard to the precise time landslides occur, which is information not usually captured on hazard maps (Sudmeier-Rieux et al., 2013; DesInventar Nepal, 2017; Aksha et al., 2018). In the absence of formal data, community memory can be the most reliable source of this information, and has previously been recognised as perhaps the most reliable source currently (Amsden and Vanwynsberghe, 2005). In this context, PMEs proved to be a very useful tool for capturing information on the timing of landslides. For example, participants categorised landslides by their recollection of when the event originally started moving, when reactivation occurred or when the most recent activity was observed. Although the temporal resolution that could be achieved was variable and the precision of recollection sometimes unclear, the events could still be divided into three time periods: (a) before the 2015 GE; (b) during the earthquake and its aftershock sequences (coseismic landslides); and (c) after the earthquake. In addition to these broad time periods, more specific details of timing could often be obtained if the occurrence could be related to an important day or festival. Although the depth of information here was perhaps not sufficient, with more detail, the timing of events could be used to raise awareness of the riskiest times of the monsoon and the most likely frequency of recurrence, and to forecast the timing of particular events in the future (Di Mauro, 2014a; Di Mauro, 2014b).

5.5.4 Knowledge exchange: Using perspective images and scientific maps

The PMEs demonstrated that they were an efficient, cost-effective tool for mapping local landslides that could be used in the future as part of local assessments of landslide hazards and risks (Acker et al., 2010; Haworth et al., 2016). In addition, as a communication tool, PMEs have been found to be widely effective for exchanging knowledge between stakeholders, both spatial and non-spatial.

Hence, as a knowledge exchange tool, the process offered 'an interactive approach using accessible and free-ranging visual methods in an individual or group interview setting to interrogate qualitative research questions' (Emmel, 2008, p. 1). The resulting maps present a clear view of participants' understandings of landslide hazards and risks, and they are a close parallel to the 'mental maps' of the risks a community faces (Wagner, 2007; Klonner et al., 2018). As such, the results from this study show the potential for knowledge exchange in which researchers, scientific groups and NGOs could work together with communities to promote dialogue, form consensus views of risks and obtain information to support communities' advocacy for support from local government (Amsden and Vanwynsberghe, 2005; Brodie and Cowling, 2010). Moreover, this approach demonstrates that communities and experts are generally willing to learn from each other, similar to the findings of Wachinger and Renn (2010, p. 36) and Williams and Dunn (2003), who observed that the gap in local risk information can be addressed, at least in part, using an approach such as this.

As presented in Figure 5-12, the output maps were overlaid with the map prepared by Durham University (Kincey et al., 2020) that shows the mapped distribution of landslides in the area. Landslides were mainly found in the eastern part of Chhyadi, where most landslide deposits appear fragile and the slope gradient is steep. In contrast, the western part of Chhyadi village has bigger landslides that are commonly clustered together. In general, it can be seen that there is a strong coincidence between formally mapped landslides and those identified by the community. The challenges in presenting scientific maps to community participants who were often illiterate and had no previous experience of map reading did mean they were initially not as interested in these maps as they had been in the perspective photographs (satellite images) shown to them. When first shown the scientific maps, participants did find it difficult to relate the landslides on the map to those in the landscape around them. However, the colours on the map legend were easier for participants to understand, and they were able to appreciate changes through time. However, there are strengths and weaknesses of using more than one base map in PMEs, and their use should be considered according to the participants' status, the purpose of mapping, the scale of local information required and local concerns (Haworth et al., 2016).

My experience in this research shows that using synoptic maps, including satellite images and perhaps UAV imagery in the future, can help to add depth to discussions about landslide hazards and risks because, invariably, landslides are visible and recognisable on these images. The PME approach also provided an open forum for discussion, and allowed for some debate about the various dimensions of risk, distinguishing between hazard, vulnerability and exposure in a manner that is not commonplace in rural Nepal. Moreover, PMEs offer an opportunity to explore community knowledge and share ideas with stakeholders, both of which help to visualise landslide hazards and risks (Gaillard and Maceda, 2009; Cadag and Gaillard, 2012; Gaillard et al., 2016). Therefore, the

PMEs offered a simple and effective means by which knowledge could be exchanged, local concerns discussed and future risk management explored.

5.5.5 Gaps in local knowledge about landslide hazards and risks

The everyday landslides that have the greatest impact cumulatively are usually small in size and impact individually, but their collective impact has been remarkably high, posing a threat to the everyday life of communities (Oven, 2009; UNDP, 2009; Chaudhary et al., 2015; DesInventar Nepal, 2017; Aksha et al., 2018; Williams et al., 2018). Therefore, the nature of these landslides, the hazards and risks they pose, how these have changed over time and how they are managed locally, are the focus of the research presented here. I identify and prioritise the following gaps in understandings of landslide hazards and risks as identified in my research to date.

1. Location, likelihood, extent, impact

Most people discuss the locations of landslides and are aware of them, and know most of the landslides around their village. However, landslide hazards and risks require more information than simply the (current) location of landslides. Ideally, it is important to understand the likelihood of them occurring, the extent of losses and the impact of continued or new landslides (Lee, 2009; Bobrowsky and Couture, 2014). These factors are part of the entire process of landslide evolution, which considers and explains how likely it is that landslides will occur, when they might occur, how large they might be and how they might behave. Critically, this includes developing an awareness of how landslides can change spatially, which involves a recognition of the distal impact of existing or new failures that are common in this part of Nepal.

2. Sub-surface geological and hydrological conditions

Several features related to developing landslides are visible on the ground, for example, the formation of cracks, but there is a limited understanding of the less visible aspects of landslide formation, for example, sub-surface activity. Often, sub-surface features, such as underground materials or geology and how they interact and/or create landslides, are poorly understood. A simple explanation of the key features that cause landslides as a result of the Earth's internal–external relationships between forces may significantly help householders and communities to comprehend the future impact of landslides (Alexander, 1992; Jaboyedoff et al., 2016).

3. Potential reach of landslide debris

In general, the risk of landslides that could have a direct impact on a community by destroying a house or road is not well understood. One example of the direct impact is the potential reach distance of a landslide (e.g. to what distance the landslide could travel), which is a commonly observed concern among villagers (Milledge et al., 2019). For instance, if the source of the landslide extends beyond the locally visible landscape, or to areas where observation of changes is more difficult, it may represent a greater risk. Therefore, it is important to be aware of those areas that are experiencing changes, and of sources of possible long-runout landslides.

4. Community-based landslide monitoring

The demonstration also has the potential for exploring ways of mitigating landslide risks. Local formal and informal observations, or monitoring, can play a significant role in local risk assessment (Stone et al., 2014). A more systematised monitoring approach could inform communities about the timing, rate of development or locations of potential risks posed by landslides. However, my research did not highlight this as a feature of how these risks are managed. Despite this, during discussions with participants, there was a clear interest in locally improvised monitoring methods that could play a significant role in protecting lives and properties, for example, periodic measurement of wooden pegs in the ground.

5. Dialogue and contesting knowledge

The opportunities for dialogue between experts and communities that the demonstration offers could provide a means of addressing several misconceptions about landslide hazards and risks. Again, based on my research, evidence of such opportunities is largely absent in communities at present.

5.6 Summary

For landslide risk reduction initiatives to be successful, knowledge of the spatial and temporal aspects of landslide-prone areas is fundamental, both in terms of a clear understanding of the hazards and risks faced by community members, and identifying what interventions are needed and where. High-frequency, low-magnitude landslide events accrue damages in excess of several million rupees (1US$ = 117.62 Nepali rupees as of 24.09.2021) in Nepal each year, and are a significant burden on the livelihoods of rural residents (UNDP, 2009; Bhubaneswari et al., 2012; DesInventar Nepal, 2017). The PMEs presented in this chapter provide a platform for compiling local landslide information that combines both spatial and temporal detail. The lessons learned from the PMEs are a good basis for similar future efforts that could contribute to local landslide hazard and risk assessments, and support the design of local DRR plans. The PMEs also helped to identify key gaps in knowledge and community information needs that will be explored further in the following chapter. It has been highlighted that there are gaps in formal landslide hazard data, such as the lack of detailed information on the timing of landslides, and a lack of sub-surface information, and there is limited acknowledgement of local knowledge in the information that *is* available. In sum, it is clear that better access to information on landslide hazards and risks would benefit not just communities but also local authorities and decision-makers. In Chapter 6, I present a novel tool for tackling this need for knowledge, information and communication.

Chapter 6

Landslide hazards and risks communication using a physical model

6.1 Introduction

Establishing an accurate, meaningful and effective exchange of knowledge between 'experts' and disaster-threatened communities has always been challenging. Being able to recognise effective ways of risk communication is a vital skill (Stewart and Lewis, 2017). A useful risk communication tool should have a constructive impact and add value in enabling better knowledge to strengthen community resilience to hazards and risks. Ideas for knowledge integration, that is, ways of combining expert knowledge with that held by communities, have attracted greater attention from DRR stakeholders in recent years. In this context, knowledge integration is a process that has consisted of both bottom-up and top-down approaches to incorporate ideas from a vast range of DRR stakeholders (Gaillard and Mercer, 2012). Hence, risk communication in the context of DRR has to be a dialogue (O'Neill, 2004; Stewart and Lewis, 2017).

Risk communication strategies are required to create desirable behavioural changes, such as reducing the exposure currently being experienced by those areas at high risk from landslides. Such strategies should incorporate local understandings of hazards and risks as perceived by local people (O'Neill, 2004). A good understanding of the nature and extent of locally perceived risks associated with common hazards, including the local context and the progression of the hazard through time, is a prerequisite for designing and implementing any proper communication tool (O'Neill, 2004).

The primary intention of communicating hazards and risks is to prevent or reduce exposure and the negative consequences of hazards, primarily by enhancing disaster preparedness, supplementing existing knowledge and providing useful new tools and options for mitigation (Bradley et al., 2014). In addition, effective risk communication tools aim to influence community preparedness throughout the various stages of the disaster cycle (Bradley et al., 2014). Similarly, giving the *right message to the right audience* to encourage risk reduction behaviour in householders or communities living in hazardous areas has always been a challenge (O'Neill, 2004). In this sense, communicating landslide hazards and risks is not a one-off activity, because landsliding has always been a dynamic process. It is also important to acknowledge that providing a space for dialogue is important and, critically, not everyone will go on to adopt the proper safety measures as communicated (O'Neill 2004). Specific to my research, a further dimension is that the nature of landsliding (i.e. pervasive but very localised, highly seasonal, highly variable from one example to the next and essentially unpredictable) also presents particular challenges for developing community understandings and communicating the nature of hazards and risks. As has been shown earlier in this thesis, it is clear that householders have limited access to information on landslides, which they could use to good effect to reduce the risks they face day to day during the monsoon.

In this research, the demonstration model aims to develop and pilot a novel approach for presenting more detailed and, ideally, useful and usable information on landslide hazards and risks to communities in rural areas. The process includes developing the new tool itself (the demonstrator), testing its operation in public (the demonstration) and assessing the effectiveness of this approach. The demonstration is intended to facilitate interaction between participants, including local community stakeholders, and to understand and build on local knowledge of landslide hazards and risks. Inevitably, in rural Nepal, landslide hazards and risks are the combined result of natural and anthropogenic factors (Petley et al., 2007; Oven, 2009; Rigg et al., 2016). Hence, the discussion during the demonstration needs to include a wide range of challenges faced by local householders and communities who live day to day with landslide hazards and risks.

The research presented in Chapter 4 and Chapter 5 suggested that local landslide hazards and risks might be better understood and information on them communicated more effectively with direct visual tools and/or methods. An interactive 3D model that provides opportunities for dialogue to promote consensus has previously been shown to have significant value (Gaillard et al., 2013). In this chapter, I discuss the development of a custom-designed live demonstration system for communicating landslide hazards and risks. The system is based on a physical model of a landslide, which illustrates in a highly visual manner how and why landslides occur. The tool has been designed to address specific knowledge gaps in community and householder understandings of landslide risk that were identified earlier in this thesis. Critically, in this respect, the demonstration process illustrates the evolution of the landslide process over time and focuses on aspects of landslides relevant to risk reduction. It aims to engage the audience and to encourage stakeholders' involvement in a dialogue on landslide hazards and risks. The chapter starts with a discussion of different types of risk communication tools. Then, in an assessment of existing gaps in landslide hazard and risk knowledge, I consider how a demonstration model could be used to communicate information on landslides in the context of Nepal. The initial review contributes to the design of the model itself, and the protocol for how it is used in demonstrations to communities and households. In the second part of the chapter, I discuss the insight and feedback obtained from communities during a series of trials. The concluding section evaluates the model to review its efficacy and potential benefits. The potential for scaling up, institutionalisation and suggestions for further research are also briefly discussed, providing a means of extending this part of my research in the future.

6.1.1 The experience of communicating landslide risk

A significant challenge for landslide DRR professionals is communicating information on the nature of landslide hazards and risks to vulnerable communities. Precisely what is deemed necessary information as opposed to the comprehensive knowledge required for DRR remains to be defined. The present study builds on previous research that has looked generally at communicating information on landslide hazards and risks, the intention of which has been to detail, strengthen and enhance community knowledge of environmental hazards (Alcántara-Ayala and Moreno, 2016). I have reviewed a number of studies, some of which have included the development of new means of communicating information on landslide hazards and risks. These studies were focused on the employment of different communication tools at the local level (householder, community), and included the use of visual tools and techniques such as maps, drawings, sketches, posters, documentaries and films, and physical demonstrations, the latter with an emphasis on dialogue (Hicks et al., 2017). Much of this literature identifies a need to map the hazards and risks being described. In general, however, risk communication models are often either too complex or too basic. For example, Wagner (2007) discussed the complexities of using models to communicate information on hazards and risks to the public, and highlighted a need for tools to be designed in such a way that they aligned with the mental models of hazard and risk people create for themselves. Such mental models of natural hazards are generally based on personal experience and information assimilated from the mass media, peer groups and responsible agencies (Wagner, 2007, p. 671).

Wagner reflected that 'the more visible an influencing factor, the better it is understood' (2007, p. 679). Therefore, visualisation is widely understood to have great explanatory power when working with participants who might have very different understandings of natural hazards and risks. To help create improved risk communication tools based on an understanding of mental models, Wagner (2007) uses flood discharge as an example, and indicates that such a tool should meet the following requirements: (a) provide a clear explanation of influencing factors (e.g. rainfall); (b) consist of an exhibition object that can be used to visualise the processes (e.g. a physical model, or object that can encourage interaction); and (c) include the use of computer models, from which people could learn how certain factors change over time (e.g. a means of adding temporal information).

6.1.2 Risk communication tools

Several communication tools have been developed that have focused on transferring scientific or technical knowledge to communities, with a two-way exchange of knowledge then developing. The most common tools in practice have been two-dimensional, for example, maps, posters, sketches and models (Moen and Ale, 1998; Haynes et al., 2007; Highland, 2008; Valenzuela et al., 2017). Among these, maps are perhaps the tools that have been most adapted for demonstrating the extent and severity of hazard events. For example, in the context of volcanic hazards in the Caribbean, Haynes et al. (2008) described the use of mapping with communities so they could understand information from other fields and appreciate the differences between scientists, authorities and themselves as the public. In addition, perspective photographs were extremely useful in helping communities comprehend volcanic risk, particularly when compared with two-dimensional maps (Haynes et al., 2007). These examples suggested that because scientific professionals are trained to interpret geospatial information for different contexts and provide precise results, this could present a challenge when working with a potentially non-literate audience unused to viewing mapped information. In research exploring the communication of spatial information in a more realistic sense, aerial photographs were recommended as having a greater level of intelligibility (Haynes et al., 2007).

Three-dimensional participatory mapping (P3DM) approaches have been used in various contexts to consider local hazards and risks, including floods and volcanic hazards (Haynes et al., 2007; Gaillard and Maceda, 2009; Rambaldi, 2010; Gaillard et al., 2013). P3DM provides the opportunity for participants to layer different thematic information on a topographical map and has been found to provide the opportunity for the participants themselves to assess threatened assets, vulnerabilities and capacities (Gaillard et al., 2013). Moreover, 3D models have proved to be useful for encouraging dialogue between different groups of stakeholders (Gaillard et al., 2013). Crucially, the effectiveness of participatory approaches depends on truly active rather than passive participation (Chambers 2007, 2008) and, in turn, active participation remains reliant on good-quality facilitation (White, 1996; Gaillard et al., 2013).

Simulation exercises are a popular means of communicating key messages with regard to how to respond to risks, and are used by many stakeholders in DRR practice. In general, simulations such as evacuation drills or multi-agency earthquake scenarios have the aim of ‘reducing the imperfections’ by following standardised protocols and using well-planned and careful responses along with reviews and feedback for further improvement (Dixit et al., 1999; Bretton et al., 2018;

Shriner, 2018). Such approaches widely utilise highly realistic scenarios played out in real time to force decisions in as realistic conditions as possible (Bretton et al., 2018), and have been shown to provide very tangible portrayals of risks to participants (e.g. Davies et al., 2015). The successful implementation of simulations relies on an explicit purpose, clear goals and firm leadership. Thus, simulation exercises provide a unique opportunity for dialogue, discussions and learning lessons based on scenarios (Bowman, 2015; Davies et al., 2015). Critically, a simulation describes how an event unfolds over time, which is not usually captured on a static map.

Visual methods, including films of varying lengths and video games, have been widely employed as risk communication tools in recent years (Mani et al., 2016; Sanquini et al., 2016a; Navakanesh et al., 2019). For instance, Hicks et al. (2017) screened a film on volcanic hazards that investigated the use of visual methods for improving knowledge about volcanic risk. The process adopted an interdisciplinary and collaborative approach to build a strong relationship between communities and the research team to ensure the output was relevant and met the audience's needs (Hicks et al., 2017). In addition, 'the product' (film) aimed to communicate locally appropriate messages with narratives to ensure the effective co-production of knowledge (Hicks et al., 2017). Similarly, Sanquini et al. (2016) used a documentary method with the aim of promoting earthquake-resistant school building construction in Nepal. This study concluded that knowledge exchange among the viewers had been significantly improved and their appreciation of what was required had increased, but it recommended that mass media interventions should be culturally appropriate (Sanquini et al., 2016a).

Live demonstrations that seek to approximate the physical processes of hazards are, potentially, powerful risk communication tools, as shown in several previous studies. These include the demonstration of causes and consequences in (model) real time, so the audience can visualise how hazards unfold. The shake table (Upadhyay, 2004; Dixit et al., 2013, 2018) is one such example that provides a live visual demonstration of the elements of earthquake-safe construction practice for residential buildings in Nepal. Here, a comparison is made between two buildings (one constructed using conventional 'standard' techniques and another using earthquake-resistant elements), which are set up on the same small (*c*.1.5 x 1 m) shake table platform. The audience can see the failure of the 'standard' house and the ensuing consequences, and compare this directly with the adjacent 'earthquake-safe' house. During the demonstration, the audience has the opportunity for dialogue with experts to clarify a range of issues in relation to the technicalities, costs and construction techniques. Over time, the shake table demonstration has gained a reputation as a powerful risk communication tool in relation to safe construction practice for buildings, but also as a vehicle by which quite complex science-based messages can be conveyed to householders or communities in a simple and easily understandable manner (Dixit et al., 2013). Further, the use of the shake table is not confined just to householders, but has been used extensively in work with DRR practitioners, decision-makers and stakeholders to help them understand the vulnerability of buildings to earthquakes (Henstra et al., 2019).

In terms of community based disaster risk reduction (CB-DRR) initiatives, community empowerment via active participations is a primary step in increasing preparedness as a means of mitigation (Petal et al., 2008; Devkota et al., 2014; Stone et al., 2014; Titz et al., 2018). In the present case, risk reduction measures can be better understood by increasing knowledge around the mechanism of the hazard so that audiences can directly observe how landslide occur. Whilst this need not be a full mechanical understanding, this brings to life a phenomena that is otherwise often unseen or not directly experienced, but remains key for really motivating behavioural change (Calvello, 2017). Moreover, the direct observation of the hazard process ensures a greater degree of ownership of knowledge that again is felt necessary to make effective risk communication (Lee, 2016). Communication is enabled through dialogue between 'experts' and 'disaster-threatened communities', particularly where the audience or stakeholders not only observe, but also evaluate the hazard process for themselves (Johnson et al., 2007; Reyers et al., 2015; Ickert and Stewart, 2016; Hicks et al., 2017; Joshi and Joshi, 2018). Following on from this, the contextualisation of the communication process allows people to relate their experiences to local practices. The aim is to increase the appreciation of precautionary behaviours, as a means of prioritising local mitigation measures, and assessing their feasibility using their local knowledge (Horlick-Jones, 1998; Heath et al., 2018; Covey et al., 2019; IFRC, 2020).

From the experience of previous similar demonstrations, that have also demonstrated underlying mechanism, ths approach has been found effective in helping people to explain visually how triggers can initiate landslide failure for instance, to better anticipate consequences over time, and to appreciate that causal factors are often interlinked (Herod, 1999; Beider, 2018). One such example is the 'citizen science' approach which draws local understandings and promotes dialogue to integrate knowledge between 'experts' and 'disaster threatened communities' or with 'non-official experts' with their own-analysis in the process of knowledge co-production (Beider, 2018). The examples shown in this thesis, using a physical model for exploring landslide hazards and risks, intend to build on local understandings, to help communities understand hazards and risks that were otherwise difficult to consider. Moreover, the diverse range of stakeholders that participate in the process of knowledge exchange adds value (Reyers et al., 2015), each of which bring different knowledges from different sources and types of together collaboratively in addressing the common problems (Armitage et al., 2011).

6.1.3 Communicating landslide risk: What is it important to communicate?

To date, traditionally, the landslide risk literature has focused on communicating information on landslide hazards and risk primarily in the form of an inventory of events, susceptibility and hazard maps, and semi-quantitative risk assessments based on the available data at different scales (Fell et al., 2008; Lee, 2009; Hearn and Hart, 2011; Hearn et al., 2016). It has been suggested that to achieve the active engagement of participants, the initial approach should be to educate, train and engage local communities that live in or near to active hazardous areas (Stone et al., 2014; Rahman and Fang, 2019). It is thought that the more people are aware of landslide hazards and risks, and the greater their understanding of these, the more the community will gain confidence and develop ideas when judging and managing risks (Alcántara-Ayala and Moreno, 2016). Three basic questions arise, and these form the basis of what I am trying to communicate by using the demonstration model. They are also directly linked to the knowledge gaps identified in the previous chapters. Importantly, these are all features of landslides that are pertinent to the risks that they pose:

1. The probability – 'what can happen?'
2. The likelihood – 'how likely is it to happen?'
3. The consequences – 'if it does happen what will the consequences be?' and
4. The mechanism – 'because of number of reasons, behind why the slope starts to move.'

The key features of landslides that need to be communicated were articulated during the household survey and PMEs (ref. Chapters 4 and 5), and I discuss these in detail below.

6.2 Aims and objectives

I aim to develop a platform from which landslide science and local knowledge can be contested by and with communities to improve landslide risk reduction practices in Nepal's hill and mountain districts. This part of the thesis describes the development of this new approach and, specifically, aims to answer the following research question:

- Can physical models be used to support communities to increase their understanding of landslide hazards and risks with the aim of increasing resilience to landslides?

By addressing the above question, the aim of this research is to facilitate improvements in the following: (a) local understandings of landslide processes and, importantly, how these change over time; (b) communication of information about the progression of landslide hazards and their subsequent capacity to generate risk; and (c) help for communities and local authorities in defining and instituting better landslide risk reduction interventions. The tool aims to communicate how the spatial distribution of landslides' progression and their resulting potential to have an adverse impact is crucial for community DRR planning. To address the research question, the following two main objectives were set:

1. Develop a physical model for the live demonstration of landslide hazards and risks that best explains the evolution of landslides;
2. Conduct live demonstrations incorporating key messages about the evolution of landslides and their progression, thereby making the case study communities aware of landslide hazards and risks.

Additionally, three supplementary objectives were set: (a) collect feedback on the demonstration from communities; (b) develop a protocol for subsequent demonstrations to help scale up its deployment; and (c) tailor the model to portray local topographical conditions (e.g. familiar ridges, streams, settlements, etc.) and major landmarks (e.g. schools, health facilities, roads and other infrastructure) in a generic pattern.

6.3 The design of the demonstrator and the demonstration

The landslide demonstration required two distinct components: the physical demonstrator, which included the fabrication of the terrain model; and the demonstration process itself. The first part (the demonstrator) seeks to provide a controllable and physically realistic simulation of a landslide typical of Nepal's middle hills region. The second part (the demonstration) includes the development of a protocol for deploying the model.

The fundamental approach of the live demonstration is to exploit the potential benefits of being able to visualise the landsliding process. The idea for the concept came after several visits to the study area after the 2015 GE. The area suffered severe damage because of the earthquake, and in the most extreme situations people had to relocate to safer land. Many others were left with latent and unfamiliar landslide risks, and no government support for mitigation, either financial or technical. Thus, a critical means of reducing risk in these locations was and remains raising awareness. Thus, there was a key need for better tools for communicating information on landslide risk. In fabricating and using the landslide demonstrator, the intention was to convey a series of basic science-based messages about landslide hazards and risks as a means of starting discussions on these topics with community members. The intention of the messages was to address directly their observed misunderstandings of landslide hazards and risks and the gaps in their knowledge about such matters, as identified in the preceding chapters.

6.3.1 Priorities underpinning the development of the landslide demonstrator and the key messages it seeks to convey

The demonstrator was intended to convey key elements of landslide hazards and risks, including their cause–effect relationships and the risks that the hazard potentially poses to households. An approach based broadly on the risk equation, which separates hazard and exposure, was adopted. The following rationale informed the design of the model.

1. Simulation of the actual mechanisms of landsliding typical in Nepal

The demonstration was developed around those types of landslide typical in the UBK. Typically, relatively deep-seated rotational landslides are common in Nepal's hill areas, and they have affected the communities who live on these slopes for generations. At times, such landslides can lead to more shallow and rapid surface failures, which pose an additional risk. The disruption to the ground surface on top of deep-seated landslides can trigger cracking and deformation over a wide area. Communities also commonly report both natural and anthropogenic causes of landslides. In designing the demonstrator, I sought to simulate the relevant trigger factors as identified by my survey respondents. The type of landslide in question closely mirrors those found in Hindi and Marming.

Conceptually, the rotational landslide (Varnes, 1978; Highland, 2004; Hungr et al., 2014) was chosen as the basis for the model (Figure 6-1) because it was considered the type that communities situated in a similar landscape (a local mid-slope bench) in Nepal could relate to more easily (Hearn, 2013, p. 138). The associated smaller-scale surface disruption, such as cracking, on top of rotational failure is a common and familiar feature, but was rarely described by participants in my research so far as being part of wider-scale slope movement. Therefore, these cracks are crucial, but underestimated, particularly when considering the risks that unstable slopes pose to many communities. In addition, a model of a rotational landslide allows progressive changes through time to be demonstrated in a controlled manner, which is more difficult with a more rapid debris flow or rock fall.

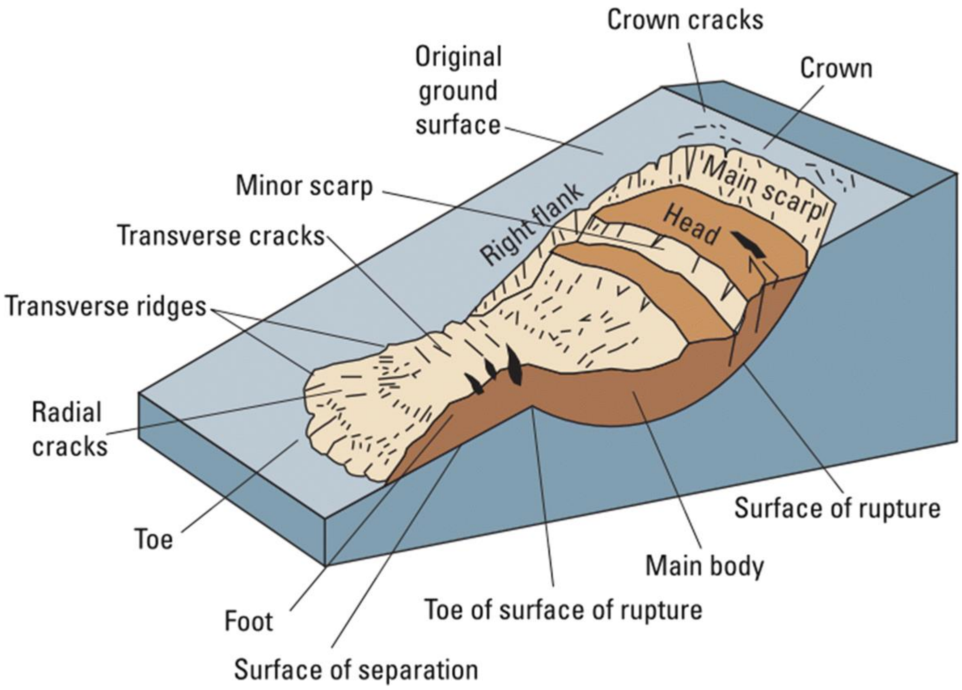


Figure 6-1. Idealised illustration of an evolving rotational landslide. (Source: Highland and Bobrowsky, 2008, p. 5/USGS).

2. Landslide change through time

The landslide demonstration tool exploits the benefit of the P3DM, which has been identified as one of the most useful tools for fostering dialogue (Rambaldi, 2010; Cadag and Gaillard, 2012; Gaillard and Mercer, 2012; Gaillard et al., 2016). Despite its potential to update 3D participatory mapping over time, this approach places less emphasis on the physical and temporal changes to landslides. Figure 6-2 describes an anticipated sequence of the progressive development of a landslide over time, which I seek to replicate in the demonstrator. This is a key factor in Nepal, where communities live alongside and, indeed, around and on top of active and dynamic landslides. The landslide demonstrator then adds the fourth dimension of 'time' on top of the 3D (see Hungr et al., 2014), providing key insights into how hazards and risks may evolve.

(a) illustration of ideal output model for reference and design purposes

(b) the output model in progress with initial cracks appearing in a specific part of the model landscape

(c) progression of failures

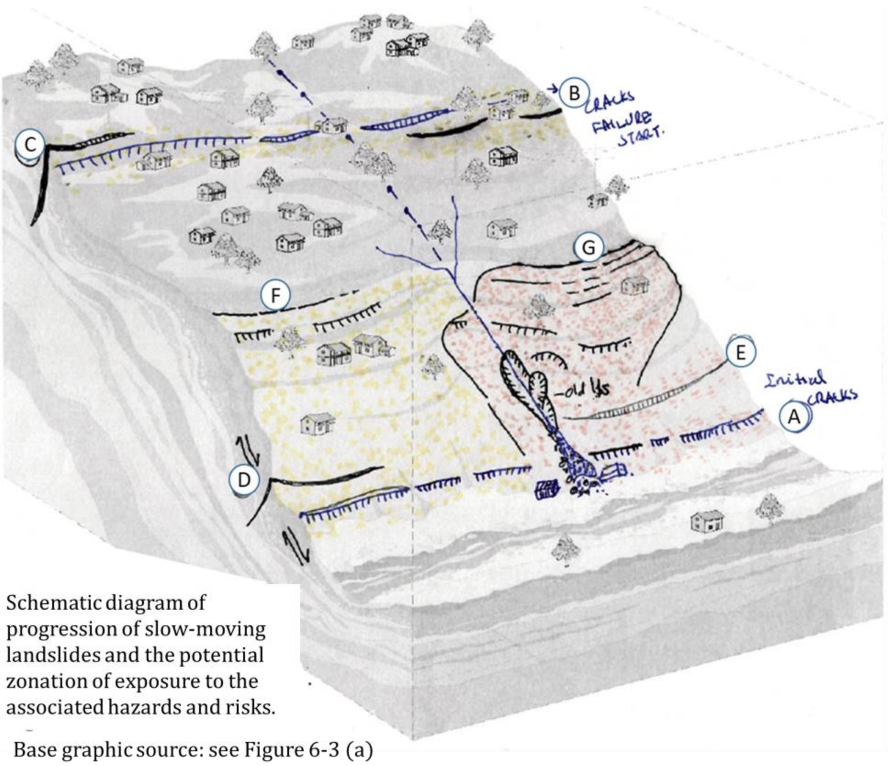
(d) progression of failures continue until the worst case scenario is reached, in which multiple failures appear in the landscape and surface failures become visible on the sides.

Figure 6-2. Schematic illustration of the landslide demonstrator, showing incremental failure progression. (Base drawing (a) by: C. D. Ranamagar/NSET).

In this research, the demonstrator was designed to include the potential for showing the changing pattern of landslide features, for instance, surface deformation. It was also intended to allow the manipulation of the landslide's progression through time (stopping and starting), thereby demonstrating the initiation of crack formation on the model and the detailed nature of further development with time incrementally. In illustrating an entire landscape with both its natural and man-made features in the form of a single unit that extended between the valley bottom and top ridge, the intention was to show how new deformation and spatial and temporal changes in developing landslides occur.

3. Making landslide hazards and risks locally relevant

The localisation of the model, whereby its features reflect the local conditions relevant to where the demonstration is being conducted, is essential (e.g. Figure 6-3), and plays a vital role in ensuring communities can relate to it. This involved the inclusion of typical village features such as houses, trees and farmland. Localisation is intended to increase ownership of the model by the participants, while also ensuring the demonstration is reproducible. In addition, the utmost care was taken not to make people scared of their villages' landscape, and to ensure they did not inadvertently identify areas at a greater level of risk than others.



A. Location of the start of initial cracks at valley bottom
B. Location of the start of initial cracks on upper ridge
C. Widening of cracks, and the appearance of signs of deepening underground
D. Another cross-section view of cracks visible underground
E. New crack formation in mid-slope areas; increasing number of cracks
F. Visible cracks in the mid-slope areas following significant damage in the valley bottom and higher up the slope
G. Increased impact, increasing hazard

Figure 6-3. Anticipated localised impact of the demonstration.

4. Separating landslide hazards, exposure and risks

Following reproduction of a local landscape, elements exposed to landslide hazards and risks were added to the model. These were local settlements, houses, schools, infrastructure, highways and local roads, electricity poles and areas of forest and grassland. Local features were represented using locally available objects, for example, grass cuttings (grassland), twigs (forest), Post-It Notes, small toys and Lego (Gaillard et al., 2013), the latter being used to represent houses, other buildings, water tanks, bridges, etc. Based on my experience from the PMEs, Lego was one of the most useful items for representing structures.

In conducting the demonstrations, I believed it to be important to separate the ideas of hazard, vulnerability, exposure and risk, as per the risk equation (Alexander, 1992), mainly as a means of thinking how to reduce risk beyond not just stopping the landslides. Realistically, reducing the exposure may be the only key risk reduction measure available, yet this was commonly not identified or conceptualised in discussions with those who took part in the survey or PMEs (Milledge et al., 2018, 2019). Separating these elements can also be an empowering step, helping people to reduce the risk when making decisions (Reichel and Frömming, 2014; Cook et al., 2018). Again, this was understood from my fieldwork (Chapter 4 and Chapter 5), because many hazards are viewed as being beyond an individual's control, as reflected in fatalistic attitudes towards landslide risk, that is, *ke garne के गर्ने!*, meaning 'what to do?' which expresses 'the problem is beyond my capacity to do anything'. In general, these statements reflect the fact that the concepts of hazard, vulnerability, exposure and risk have overlapping meanings in rural Nepal, as also understood from the survey and PMEs. Differentiating between such elements during the demonstrations required a clear explanation and justification in the context of how this could reduce risk.

5. Logistical considerations: Cost

In designing the model, the intention was to use only materials from the local market, keeping the total cost of model production low (less than a few hundred dollars). The construction of the model required the following: (a) a supporting frame; (b) materials for creating the model landscape; and (c) items (for example, Lego) to represent features. These materials can all be reused or reassembled as required. The cost of the professionals' time to run the demonstration was not included here. In this sense, the demonstrator's cost is low and, indeed, compares favourably with other standard landslide mitigation measures, for example, the cost of buying and installing gabions. Hence, the consideration of cost-effectiveness has been one of the key aspects of the trials (Starr, 1969; Dixit et al., 2000; Wachinger and Renn, 2010).

6. Ease of replication

It was crucial to be able to replicate predictable behaviour during multiple uses of the model and, therefore, a consistent and speedy protocol for presenting the model had to be developed. After several iterations, the model described below is designed to be rebuilt in two to three hours without a need for significant expertise. It should be noted that it would be possible to publish the detailed procedure for construction in both manuals and short videos for future upscaling.

7. Transportability

A key issue in the design of the model was ensuring that communities at risk from landslides could access or see it and, hence, that it could be taken to the appropriate locations. Therefore, in terms of its dimension, weight and other properties, the model was designed to be carried on local roads, and so was built as to be easily portable on the back of a 4x4 pickup. Although the model was too large to be carried by porters, I concentrated on locations with rural road access where available. I note that the size and scale of the model are important to make it as visible to the audience as possible and, naturally, larger models offer benefits in this regard; ultimately, however, this had to be balanced against the other considerations outlined above.

8. Scale representation

Showing a more precise representation of the landslide process presents more opportunity for dialogue on the event's causes and effects (Smillie and Blissett, 2010). As the model becomes bigger, the physical mechanisms also become more similar to those operating in real slopes and, hence, the model may be considered to be more realistic. A critical aspect here was that a model large enough to enable a slope to fail under its own weight, as in a real slope, was of too great a size to be built in a practical manner, which is a challenge for studies using physical analogue models of landslides. As a result, an alternative means of mobilising failure, which would operate at a smaller scale, was needed, as described below. The visibility of features on the model was also a key consideration for model scale. For example, the features associated with poorly managed development of roads, such as erosion from runoff, were deemed to be important to replicate, but became too small if the model was not of a sufficient size and scale. A model box of 90 × 60 × 60 cm, representing a hillslope in the order of *c.*1 km in length and 500 m in width, formed the approximate dimensions of the modelled scenario.

9. Visual appeal

One of the things learned from NSET's shake table demonstration for explaining the resistance of buildings to earthquakes was that the demonstrator should explain the complex scientific concepts in a simple and visual manner. Participants had to be able to relate cause–effect with regard to landslides (e.g. rainfall as a trigger factor, or the role of road construction) to what they saw in their local landscape. This was also reflected in trying to make the model realistic through the use of appropriately coloured materials (e.g. green for vegetation, brown for soil, grey for rocks). Again, these were intended to increase the realism of the model. Hence, the design of the landscape was intended to be in a visually appealing format that could convey the risk messages in an appropriate manner (Moen and Ale, 1998; Paul et al., 2021).

6.3.2 The design of the landslide demonstrator

The demonstrator's detailed technical design and fabrication are described in Section 6.3.3 and Figure 6-4. The model itself briefly comprises a framework made of steel within which the rest of the structure sits. The rigid, fixed base represents the immobile bedrock topography that is roughly parallel to the ground surface above; the latter represents the shear surface, over which an overlying plastic sheet is pulled downslope using a crank handle that drives the landslide movement. The landslide mass consists of material placed on top of the plastic sheet, and surface features, such as houses, are added. The topography is shaped to reflect a typical rural hillside in Nepal, with housing, trees, a drainage network and rural roads, as shown in Figure 6-5. Below, in an explanation of the wider demonstration protocol, I describe how features on the model evolved.

Figure 6-4. Model building in progress and dimensions of the model (left); and finalising landscape decoration ready for demonstration (right).

Figure 6-5. A close-up view of the model's surface, showing the ground features that have been imagined using locally available materials, small toys and Lego.

6.3.3 Design of demonstration for presentation in the community, and key messages

In this section, I explain how the demonstration is conducted in communities. The key messages conveyed by the model are divided into five categories that unfold during the course of the demonstration. The process includes a series of questions that are used to guide the accompanying discussion and to gauge participants' current understandings, which the answers are intended to enhance. This protocol was initially developed in English and then translated into Nepali; finally, the whole demonstration was conducted in Nepali. The content of the demonstration is provided in Table 6-1 (Demonstration themes A–E), and is explained in further detail below.

Table 6-1. Broad themes covered in a live demonstration, and a brief explanation of each, including content and guidance points

Themes	Issues covered/starter questions	Remarks, and prompts given to participants during demonstrations
A. Landslide hazards.	What do you think about landslides? Why do landslides occur? Where do they occur? When do they occur?	These questions are simply intended to start a conversation, particularly in relation to what geographical or ground conditions are thought to cause landslides. Where are landslides located (next to houses, buildings, next to the village or elsewhere, how close, how far?) How do they know what the geographical distribution of landslides in their village is? How are these events related to their household or villagers' problems?

Themes	Issues covered/starter questions	Remarks, and prompts given to participants during demonstrations
B. Local engagement in knowledge about landslides (landslide disaster risk reduction).	Who is the most knowledgeable about landslides in your village or community? Who is most concerned about landslide risk management in your community/village?	Who has the better knowledge about landslides (e.g. children (boys or girls), elderly people, teachers, people from outside (the village), 'experts' (or outsiders)) or who else? Who is responsible for landslide hazard and risk management (e.g. individuals (yourself), village (your own community), ward (administration), *gaunpalika* (local authority, rural municipality), central authorities)? Or, who else?
C. Perceived landslide hazards and risks at the local level.	What is the potential likelihood of a landslide in your village? What do you think the possible losses due to landslides (if they occurred) in your village could be in the future?	In this part, three elements are presented and discussed: (a) the potential extent of landslides; (b) perceived risk of damage; and (c) how householders consider future damage. The strength of the response might range from 'not at all' to 'a lot', and the content of the response might include the threat to family members, villagers, livestock, farmlands, schools, local roads and/or infrastructure.
D. Risk reduction initiatives, responsibility for landslide disaster risk reduction and management.	What specific measures have villagers taken for the protection of houses and farmlands? What specific measures can be taken? Are these measures technically or financially feasible? Who is responsible, or what can a community do to mitigate the effects of landslides?	Facilitate discussion of current measures or practices for landslide mitigation. Focus on what the audience thinks about specific measures that need to be taken for landslide risk mitigation. These measures could be either technical, related to management, or whatever is financially feasible. Are these measures applicable to householders or communities at the local level? What are the expectations of the audience with regard to local and external support?
E. Participating audience's reflections on the landslide demonstrator and the demonstrations.	Was the demonstration useful? What information was new? Was the conversation understandable? What can be done to improve the model? In your opinion, what must we add? Is this model useful for further replication or demonstration?	Anticipated results: that there will be active participation from local community members, including local villagers, women, elders, local representatives, officials, teachers, students and parents. Response: collect participants' reflections using every means possible (including personal conversations, answers to questions, and audio and visual records as possible and when convenient). Reflection: (a) does this demonstration meet the audience's expectations in relation to local issues? (b) does it cover local issues and problems? (c) the usefulness of the model, the effectiveness of the presentation procedure and the comprehensibility of the dialogue; (d) is the language understandable (not too

Themes	Issues covered/starter questions	Remarks, and prompts given to participants during demonstrations
		technical, too simple?), is meaning lost through not being able to understand terminology or there not being local words for what we are trying to explain? (e) take comments into account to help participants better in the future.

I now describe each of the steps listed in Table 6-1 that form the basis of the community demonstrations.

A. Use of the evolving model to understand landslide hazards and risks at the local level

The first step starts with an introduction to the model. This included a brief discussion of the modelled surface, that is, slopes, rivers, buildings, local roads and highways, and trails, and the features that were added. Next, the demonstration proceeds in steps, showing how the landslide changes over time (Table 6-2 and Figure 6-6). The progression of the landslide is driven by pulling the crank slowly (see Figure 6-2(c) bottom left), which slowly displaces the landslide mass above the shear plane. This process initiates the ground failure and, as a result, the landslide's typical surface features, such as cracks and deformation of the surface topography, start to develop and become visible (Figure 6-6, step 1–4, and Figure 6-2(a–d)). These features are described and explained in Table 6-2.

Table 6-2. Outline for explaining the features of the local landscape that represent landslide hazards and risks over time

SN	Features	Key messages	Demonstration points	Other remarks
1	Background, introducing the model and its relationship to the local landscape.	A general overview of features in the landscape, including landslides. Consideration of why it is important for us to understand landslides.	Familiarisation with the landscape shown in the model.	Starts with a very general introduction to the local landscape, and explains the overall geography of the modelled landscape. Introduce landslides, interact with the audience and find out about their thinking in relation to landslides.
2	Trigger factors, initiation of ground failure – cracks and	The initiation of ground deformation, start of cracking, crack progression and the appearance of new cracks.	Identify and show initial deformation. Show conditions leading to failures.	When the beginning of the failure process starts, show first where landsliding occurs, and then how it progresses. Explain how the timing of landslides relates to the calendar (seasonal or yearly differences).

SN	Features	Key messages	Demonstration points	Other remarks
	other deformation.	Landslides over the model's surface area. Show how their impact can change over time.	Show which part of the model starts to fail and how it progresses – cracks or any other changes.	Additional, new or recurrent landslides are observed and explained, and discussed. In which part of the valley do most landslides occur? Explain and discuss the reasons why they start here. Explore natural and/or anthropogenic reasons for landslides.
3	Distribution of landslides on the model.	Where landslides occur and how they are linked.	The distribution of landslides over time.	This is demonstrated with further downslope movement when cracks widen and join together, putting houses and roads in danger, but very much dependent on their location.
4	Extension of landsliding areas, emerging lines and size of cracks.	Potential for merging of landslides Impact?	The importance of observing entire landscape change over time.	Aim here is to explain how cracks or deformations develop, and to highlight in which direction failure progresses. Comment on the typical distribution of failures, such as on the top ridge or in the valley bottom.
5	The overall impact on the area.	How the landscape changes over time.	Observation of locations subject to the most severe impact.	Consider how these forms are related to which part of the village or valley.
6	What other aspects are significant?	Other causative factors such as deforestation, road cutting, and where these typically occur.	Discussion, feedback, reflection.	Audience input into understanding of conditions necessary for landslides to occur and trigger factors in the valley, as informed by the ideas shown in the model.

The behaviour of many slope movements evolves over time (Flageollet, 1996; Hungr et al., 2014). One consequence is that landslides rarely occur without some form of warning, such as the incremental development of cracks, which provides vital information of potential value for reducing risks. This incremental process of slope deformation can be observed during the demonstration. It should be noted that in each demonstration, the material used in the model closely reflected the features being depicted, with considerable variation between different mixes of soil, water and sand. Figure 6-6 shows the resulting typical stepwise progression of the surface deformation and features as the demonstration progressed.

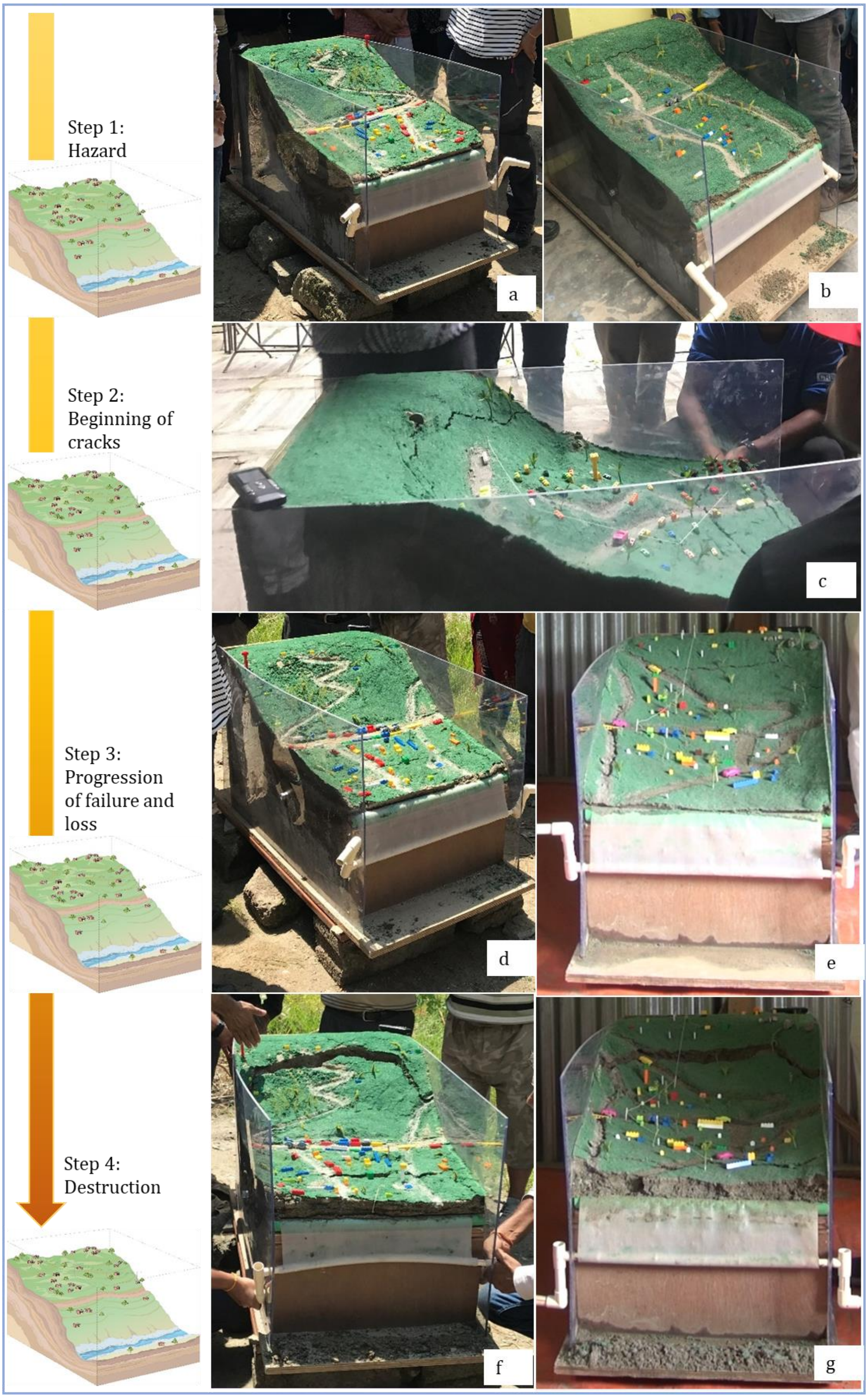


Figure 6-6. A tailored, simulated experience during a community demonstration, showing progressive failure and how hazards, exposure and risks change over time.

B. Exposure and risk posed by landslides and risk management

The aim of this step is to demonstrate the concept of exposure to landslide hazards; here, the demonstration focuses not only on the distribution of exposure but also on changing exposure, exploring the idea that exposure varies across the surface of the model. Exposed elements relative to landslide hazards were visualised, whereby some areas are evidently safer, and some riskier, as described in Table 6-1 (Stage B), and Table 6-3. In this section, the demonstration is intended to draw participants' attention to how risk (rather than hazard) evolves over time. The influence of proximity and relative position is taken into account to consider the potential threat posed by landslides.

This part of the demonstration was intended to explore the future impact of landslides on households, because landslides change over time. Here, I briefly also discuss the responsibilities for LRM, and current risk reduction and management practices. Although the model is not a complete or perfect replication of the local hazards and risks, it demonstrates the role of exposure in generating these risks.

Table 6-3. Outline for explaining the exposure of elements or features to landslide hazard and the role of landslide risk management at the local level

SN	Theme	Features demonstrated	Key messages	Other remarks or narratives
1	The risk to exposed features.	Distribution of natural and man-made features across the model. Physical features located in various parts of landscape, and the importance of their relative position.	Location of exposed elements. Observing the potential impact of landslides across the area.	How are these elements distributed across the area? How are these features exposed to a landslide?
2	Hazard, exposure and risk changes over time.	How risk has been changing over time, and how it may change in the future due to new landslides appearing, or seasonal changes.	Observe the changes in landslide hazards and exposure to these over different time periods.	The potential impact on exposed features and whether the risk is increasing or decreasing. Whether the previous losses are likely to become worse in future and what might be expected.
3	Risk management.	Who is responsible for	Clarity with regard to the responsibilities of	The conversation begins with stakeholders' responsibilities – individuals, households, communities,

SN	Theme	Features demonstrated	Key messages	Other remarks or narratives
		local risk management? Who is the most concerned? Who is the most knowledgeable about landslide risks locally?	local government, communities and householders. What can be done locally? Within or beyond the capacity of the community?	wards, *gaunpalika*, central authorities and others. Who is the most concerned about local landslide disaster risk reduction and management at the village level? Interested local stakeholders, for example, ward (administration), village (the community you live in), central authorities, *gaunpalika* (local authority or rural municipality) or who else? What is the role of the community in landslide disaster risk reduction?

C. Challenging community understandings and misconceptions about landslide hazards and risks

In this session, the live demonstration encouraged participants to relate the demonstrator's behaviour to their own observations and experiences of their landscape. The demonstration focuses on the general understandings of local people, and how communities understand and explain the impact of everyday landslide hazards. Building on the survey results, the emphasis of the demonstration was on providing a wider context for the moderately severe damage that can have an impact on a householder or community and commonly dominates people's concerns. This part of the demonstration builds directly on earlier discussions of participants' perception of the threat posed by landslides. Hence, this part of the demonstration aimed to enhance local understandings by visualising these issues directly using the model. The outline of this part of the demonstration is presented in Table 6-4.

Table 6-4. Outline for explaining the changing hazards and risks faced by local communities

SN	Features	Key messages	Demonstration points	Other remarks
1	About local landslide risk.	Showing existing landslide risk across the area. Anticipation of future damage, consequences of landslides. How big was the impact, and what	Where is the damage concentrated? Who experiences the most severe impact?	Could it have an impact on your household or/and community? Who will be the most affected? What will be the damage – loss of life, properties, assets, for example, disruption of trails, roads, loss of farmlands, damage to property, displacement (household only or entire settlement)?

SN	Features	Key messages	Demonstration points	Other remarks
		could it be in future?		Impact on daily life, for example, travelling to the local market, school, health facilities, etc.
2	Local mitigation efforts with regard to landslide disaster risk reduction – household level, community level? Community role in landslide disaster risk reduction?	How has landslide risk changed over time? Are any mitigation efforts in place? What role does the household or community play, or what does each contribute?	The progression of cracks can increase or decrease the risk in the short term and longer term for households and communities. Can it be avoided or can the potential for loss be reduced?	Show (by using the model) the extent of potential damage a landslide in your village could cause. The answers might be 'not at all', 'some', 'a lot', etc. Ask the audience what they predict the possible loss to the village (that is, your community) and its surroundings could be in the future because of the landslide. Have you made any efforts to protect your house from landslides? Please share your experiences.
3	Local roles in landslide disaster risk reduction.	Facilitate a discussion on how a householder or community can contribute, thereby playing a role in landslide disaster risk reduction.	Householders themselves can initiate mitigation and risk reduction measures.	What can be done locally? What is beyond the capacity of an individual householder or community? Role of community members? Role of external 'experts'? Role of local authorities? Or, who else? How could all these come together?
4	Who is responsible for landslide risk mitigation?	Stakeholders work together to practice landslide disaster risk reduction and make the community safer.	Encourage the audience to think about it.	Leads to the next level of discussion, which is what role the community would play in different activities.

D. Community role in landslide risk reduction

This part of the demonstration explores the role of the collective efforts of the community in landslide risk reduction, and it focuses on the importance of local actions carried out at the individual, household and community level with the aim of increasing community safety in relation to landslide risk (Table 6-5). The session included discussing the feasibility of different measures, who might introduce these and the potential role of landslide monitoring at the local level. A number of potential actions are presented, bearing in mind those that would be feasible locally within the limited resources available.

In this session, I asked the audience to provide their personal opinion on what measures could reduce their landslide risk. As per the household survey and PMEs carried out earlier in this research, the demonstration then explores feasible options, including low-cost local monitoring and the types of risk information this can generate. The previous experience of local monitoring using simple stakes in Chhintang (Dhankuta District of Eastern Nepal) and Chhyadi (UBK) as part of the Earthquakes without Frontiers project (NERC, n.d.), and as reported earlier in this thesis (Chapter 5), was discussed during the demonstration. Low-cost monitoring like this can be reproduced on the demonstrator, albeit at scale, thereby showing it can capture landslide change and, therefore, risk over time. The discussion included how this could be undertaken, the data it can generate and what the data can be used for, including estimating rates of land loss, and advocacy to local government for support. This part of the session focuses on demonstrating the types of measures that could be undertaken, and then discusses their feasibility, the role of low-cost local monitoring and the role of the community in local risk reduction.

Table 6-5. Outline for explaining the role played by the community in landslide disaster risk reduction

SN	Themes	Mitigation measures available	Demonstration points	Other remarks
1	Community mitigation measures for landslide diaster risk reduction.	Type of mitigation measures the community could afford and introduce with local resources.	Explain briefly the difference between structural and non-structural mitigation measures in relation to landslide disaster risk reduction.	Facilitate dialogue about what mitigation measures the participating audience could adopt, and consider how feasible they are.
2	Role of the community in landslide risk assessment.	What can be done locally to ensure local risk information is taken into account in risk assessment?	Locally feasible methods suitable for the area where we live?	Because risk assessment is important in local decision-making, discuss how this can be undertaken.
3	Monitoring.	What is landslide monitoring? How can it be implemented?	Benefits: monitoring landslides to save lives; preparedness planning.	Are all methods of monitoring equally useful? What type of monitoring could be suitable here? How useful will landslide monitoring be if low-cost techniques and resources are used?

SN	Themes	Mitigation measures available	Demonstration points	Other remarks
4	Local monitoring.	Monitoring. Illustration of examples, such as the use of stakes.	Observe the movement of stakes, and the interpretation of this.	Explore what monitoring is and what is can be used for.
5	Local changes are important in relation to how monitoring can help.	Observation. How the position of the stakes changes – inclination, movement, etc.	Explore how such a system could be implemented locally.	Discuss feasibility using examples from Chhintang and (now) Chhyadi, based on engagement of local volunteers.

E. Debriefing and conclusion with regard to take-home messages

The session concluded by thanking the audience for their time and active participation. Post-demonstration sessions were found to be beneficial for those participants who were less vocal and, therefore, less actively engaged, potentially because of gender or demographic characteristics (Holcombe et al., 2018). Several simple take-home messages were briefly reviewed at the end of the session.

F. Feedback from the audience

During the trials, one of the key activities of the live demonstrations was to collect feedback from the audience. The reasons for doing this were as follows: (a) to appraise the value of the model to the participants; (b) to assess the influence of the model on people's understandings of landslide hazards and risks; (c) to evaluate current understandings of landslide hazards and risks, according to which future activities in the same community can be determined; and (d) to make improvements to the demonstration in the future. Feedback was collected using formal and informal means with the oral consent of the audience, as per their convenience and comfort.

Several possible and convenient ways were considered for collecting feedback: quick questions, video clips, audio recordings and brief personal conversations. In most cases, a written response was not possible, but when it was, this was collected using a designated feedback sheet (see Appendix 9), along with a collection of verbal responses and audio and video clips for future reference. An additional means of collecting feedback was via continuous observation during the demonstration. Given the limited number of staff present during the demonstrations, this was one of the most convenient ways of collecting feedback.

The feedback sheet with accompanying guidance notes was prepared beforehand and as summarised in Table 6-6. Feedback from the audience was mainly sought on the following: (a) their impression of the efficacy of the live demonstrator in representing local issues and problems; (b) their thoughts with regard to the usefulness of the tool in conveying landslide risk reduction messages; (c) their opinion on the approach, that is, the model itself and the demonstration process; and (d) suggestions for improvement, including any elements that should be included in future, and any other comments with regard to the language, the presentation skills of the person carrying out the demonstration, location of the demonstration, people that should be included, etc.

Table 6-6. Feedback sheet provided to audience and collected after the demonstrations (both trials and live sessions)

SN	Feedback	Guidance notes
1	Your impression of the model	Its usefulness or effectiveness, physical attractiveness of the model, overall ability to do the job we want it to. Does it make sense for communities?
2	Your thoughts on the message explained during the demonstration	Did it help you in understanding the landslide process, hazards, risks? Was it helpful in understanding the role of mitigation measures taken at household or community level?
3	Suggestions for improvement	Any suggestions as to how the landslide demonstrator itself or the way it was demonstrated (process followed) could be improved? How useful was the message conveyed and how effective was the way it was delivered?
4	Additional comments	Any suggestions in relation to localised context? Does it apply to *this* local context? The delivery language, was it too technical or too simple? (at NSET only) Do you suggest this model should only be trialled with audiences who are already familiar with the shake table?
5	Other remarks	Anything else participants would like to add.

Participants' feedback provided a useful evaluation of the demonstrator and demonstrations and, therefore, valuable information as to how to approach subsequent demonstrations. Once collected, the examples of feedback provided in Appendix 10 were referred to in future discussions.

6.4 Trialling the approach

The purpose of trial demonstrations was to test the demonstrator's proper functioning from a physical and mechanical point of view (Figure 6-7) and to evaluate the efficacy of the key messages it was hoped it would deliver during the community demonstrations. The demonstrator was initially tested with audiences of technical specialists through a series of workshops in Kathmandu. The full demonstration was then tested in communities in Sindhupalchok District in the UBK at dedicated events. These trials were used to develop the dialogue for the presentation of the model, and to conduct the evaluation of the approach as presented in the discussion below.

6.4.1 (1) Technical specialists and expert group

The first trials of the model, which covered its ability to simulate a landslide, were conducted using a prototype. These were conducted at NSET in Kathmandu with technical specialists (academics, practitioners, DRR policy-makers). A further trial, which was aimed at achieving a more comprehensive run-through of the full demonstration, was conducted with NSET professionals (engineers, DRR practitioners, social mobilisers). This demonstration (14 August 2019) involved about 25 participants, from whom feedback was incorporated before the community demonstrations took place.

(a)
the first observation of model performance among research team along with supervisory team

(b and c)
among the larger audience in front of a mixed audience including experts, practitioners and laypeople at NSET premise, for feedback and need improvement before deploying for community demonstration.

Figure 6-7. First full-scale multiple trials at NSET premises observing the model's performance before community demonstrations.

During these trials, the aim was to present the techniques used by the demonstrator and to anticipate any problems and challenges likely to be faced during its subsequent development. The trial demonstrations focused on five major themes, the exposition of which was intended to promote confidence in the model's behaviour, vital for the community demonstrations. First, my aim was to test the overall physical performance of the model, and its ability to replicate landslide behaviour. During the trial demonstrations, I focused on understanding the nature of the slope movements generated, how realistic these were and on addressing any issues associated with the model's operation, particularly in relation to the reproducibility of the results. Second, it was necessary to test the ability of the model to control how a simulated landslide evolved over time. The full trial demonstration was conducted in front of experts, who, based on their own experiences, evaluated the quality and clarity of the model, particularly with regard to its suitability for presentation to communities.

This series of in-house demonstrations led to significant refinement of the model in relation to its operationalisation, its functionality during demonstrations and the clarity of the key messages to be delivered. The trials had three main outcomes: (a) confidence was gained by testing the model in front of a live and critical audience; (b) development of a standard procedure for the demonstration to follow each time it was deployed; and (c) consolidation of a set of key messages arising from the demonstration. These suggestions and recommendations were found to be in line with the audience experience of the NSET shake table demonstrations (Dixit et al., 1999; Dixit, 2003; Upadhyay, 2004).

6.4.2 (2) Community demonstrations

Community demonstrations were conducted in front of audiences at a number of locations in the case study communities in the UBK (Hindi, Chaku and Marming). Five demonstrations in total were conducted (Table 6-7), four in on-road locations (Chaku and Hindi) and one in an off-road location (Marming). Because of seasonal restrictions, the demonstrations had to be conducted where road access was possible. The event was advertised and coordinated with local government ward chairs and was made possible because of my existing links with these communities. The local authority also formally assigned a municipality staff member to coordinate with local communities to legitimise the demonstrations.

Table 6-7. Community demonstrations: Location, date, premises and audience

SN	Location	Type of premises	Participation	Audiences
1	Hindi (on-road) 20.08.2019	School premises (on open ground) in front	*c*.40 Male and female, teachers,	Local villagers in Hindi of different ages and ethnicity. Mostly from roadside households.

SN	Location	Type of premises	Participation	Audiences
		of school building	villagers. Male dominance.	Included teachers from both inside and outside of the valley and upper-grade higher secondary school students. School administration recommended students' participation, considering it would educate them about landslides.
2	Chaku (on-road) 21.08.2019	On open ground next to highway/bazar area	*c*.25 Mix of male and female participants.	(Phulping side of Chaku) Residents, locals and people from surrounding villages (valley people). Participants of different ages and from different occupations and educational backgrounds.
3	Marming (off-road) 23.08.2019	School building (school *danda*; open building, shade)	*c*.50 Mix of male and female participants.	Local villagers, teachers and students in secondary grades 9 and 10. Several teachers were from outside the valley. The majority of participants were local residents from the area around the demonstration site.
4	Nayapul – The Last Resort (hotel) (on-road) 24.08.2019	The Last Resort – shed within hotel compound	*c*.25 Hotel staff and others, almost equal number of male and female participants.	The resort (hotel) staff. Local, from surrounding villages. Homogenous audience in terms of age, local origin and education level. Mix of male and female.
5	Chaku (on-road) 25.08.2019	School premises (Marming side; inside the school hall)	*c*.50 Mix of male and female. Students, teachers, villagers, shopkeepers, etc.	School teachers (from outside the valley), students (Grade 9 and Grade 10 (*c*.15–17 years old)) and villagers living in Chaku.

Once all the preparations had been completed, the live demonstration began with introducing the team members, the aims of the demonstration and the tentative schedule, and by giving any necessary 'housekeeping' information. The demonstration then followed the stepwise activities described in Section 6.3.3. Below, I summarise the results from the entire process of the development of the landslide demonstrator, including the creation of the physical model itself and the content of the demonstration. I also discuss the take-home messages as outlined in Figure 6-2, and provide a summary of the community feedback in relation to the model.

Figure 6-8. Community demonstrations to different audiences: (a) mixed audience (students, teachers and villagers in Hindi); (b) local people in Chaku; (c) and (d) teachers, students and local villagers in Marming.

6.4.3 Limitations of the approach

The demonstrator and demonstration have some limitations. In developing the landslide demonstrator, the intention was to facilitate a meaningful discussion about landslide hazards and risks, trigger questions about these and encourage communities to think about them. In this respect, the model was mostly successful; however in the context of Nepal, social barriers can still prohibit full engagement by all in the community, including some who do actually participate to some extent. Inevitably, decisions had to be made to simplify the approach and the situation that the model sought to replicate. For example, when building the tool, it had to be restricted to the most common type of landslide, and the demonstration itself only focused on the most pressing issues that can be realistically addressed within the constraints of the resources available to the community. As a result, the model cannot represent every landslide type, or every issue that communities may raise. One consequence is the risk that some may not view the model as being of any relevance to them, and this was experienced in some locations. Another limitation of the tool has been the extent to which it can represent features taken directly from the local landscape. The representation has remained broadly indicative, and the generic landscape constructed in the model is not necessarily intended to replicate a specific local terrain. Because it was to be a communication tool, the materials used in the model's construction were chosen for their ability to produce reproducible behaviour in the model. This was not laboratory-based testing of strength, but rather the replication of the features as observed on the land surface around the village. It should be noted that available materials varied significantly in character, and so the model's behaviour in each demonstration was likely to be slightly different.

One consistent element from the modelling was the ability to control the evolution of the landslide over time, which is directly controlled by pulling the plastic sheet. Obviously, this is a marked departure from the natural way in which a landslide occurs, which was clearly apparent to the participants. In initial tests, there was some confusion as to what exactly the plastic sheet represented. This was tackled with a clear explanation and a focus on the landslide's consequences, rather than on the detail of the underlying drivers. In general, it was crucial to concentrate on the clarification of misconceptions, and the highly reproducible behaviour of the model was invaluable in being able to explain precisely the movement observed in each successive demonstration.

Another constraint of the landslide demonstrator was providing access to the demonstration sessions for all members of a community who are potentially affected by landslides. The model was clearly of value for those who were able to gather round it and be physically present at the sessions. Those within the community who felt unable to participate due to gender, age, caste or other similar reasons reflect common entrenched problems that stratify, discriminate against and privilege participation in Nepali communities. A final factor was that the nature of the demonstration (it was based on a model) led many to assume it was designed and intended for use with school children. Obviously, this was not the original intention of the model, but this perception did influence suggestions about where the model should be deployed and for whom, when discussed with the local government.

In the next section, I discuss the outcomes of the 'demonstrator' and the 'demonstration' based on my own experience, local impressions and the feedback collected.

6.5 Discussion and conclusions

> this tool gave us a highly accurate account of our local landscape, information, describe the potential of landslide hazards and risk, are well-demonstrated in the model
>
> Teacher in Chaku (from Marming, BL/M c. 35yr)

The intention of this study was to lay the foundations for the future development of a new type of landslide demonstration tool for use in landslide risk reduction efforts in Nepal. This approach has been shown to hold potential as a platform for knowledge exchange between communities and DRR experts, and enables all stakeholders to experience some degree of learning, as was clear from the feedback on the demonstration. For instance, a head teacher in Marming said, 'this should be demonstrated in every school' and 'among all students and teachers at our school should participate in this demonstration, the landslide has a problem extensively around'. The live demonstration aims to add more detailed information on how and why landslides change, and what this means in terms of the hazards and risks that people face. Further, the tool aims to complement local understandings by better articulating what is possible in terms of landslide risk reduction. Specifically, when people are presented with the opportunity to directly observe a problem, the role they (individuals and communities) can play in mitigating landslide hazards and risks is demonstrated admirably.

The results and findings based on these initial demonstrations are summarised below. Although the time I had to complete this final component of my research was limited, meaning that a more longitudinal study of the uptake of messages or changes in knowledge as a result of the use of this particular approach was not possible, I am still able to focus on the reaction of the participants and give my own structured appraisal of the success of the demonstrations. The discussions focus on the following: the significance of the demonstrator for communicating landslide hazards and risks; the demonstrator's ability to convey key risk reduction messages; the demonstrator as a tool for knowledge integration, raising awareness and advocacy; and the potential for upscaling in future use.

6.5.1 A novel tool for communicating landslide hazards and risks

This work has devised a new risk communication tool: the landslide demonstrator. The rationale for the tool emerged from the household survey and community-based PMEs, and it was developed in response to an extensive exchange of ideas among professionals working on DRR. It became clear there was a demand for realistic (in this case, 3D) live demonstrations that were locally relevant, to help communities develop a better understanding of everyday landslide hazards and risks (Mani et al., 2016; Stewart and Lewis, 2017; Haferkorn, 2018). The demonstrator was also developed in relation to other forms of engagement (and entertainment) in rural Nepal that have become widely used in community-based DRR interventions: street theatre; awareness-raising programmes; exhibitions on earthquake safety; ESD; shake table demonstrations; orientation programmes that encourage communities to participate actively; and encouraging dialogue through public conversations (Dixit et al., 2013). In developing the demonstrator, it was vital to utilise the lessons learned from the similar approach taken by NSET's shake table. In summary, the key elements that the model has uniquely been able to demonstrate are as follows:

1. How landslides evolve through time
2. Key indicators of developing landslides;
3. Identifying historical inactive landslides;
4. Identifying and/or mapping areas at risk;
5. The distinction between landslide hazard, exposure and risk;
6. Measures that can control landslides;
7. Different types of landslide;
8. A synoptic and relatable perspective at the whole landscape scale; and
9. Monitoring as a means of mitigation.

The demonstrator allowed participants to observe the initiation and progression of ground deformation over time. Therefore, they were able to see the nature of the evolving risks posed by landslides that are not commonly seen in day-to-day life; typically, most landslide change occurs in locations out of sight, at night or during heavy rain. The causal relationships between different landslide trigger factors and their indicative signs in the landscape was an additional element shown by the model. Being aware of such causal chains of hazards and risks is a key factor for reducing the risk and improving decision-making, because single hazards rarely act alone (Stewart and Lewis, 2017; Henstra et al., 2019; Safford and Brown, 2019). Again, a critical element here was the temporal dimension of the model, showing how these trigger factors could recur over time in response to changes over seasonal, annual or multiple timescales, especially during the monsoon. Further, the model was sufficiently sensitive to illustrate the influence of relatively small-scale changes on wider slope stability, as one respondent observed, 'Yes, the model … [is] … remarkable for an understanding of the landslides, and showing how the little disturbances can affect in the natural phenomena' (from written feedback, NSET demonstration).

The demonstrator was also able to show a clear link between internal and external (surface) ground movements that can be highly damaging, if not fatal. Critically, the model enabled these to be linked to processes of deformation that were ongoing underground (Highland and Bobrowsky, 2008;

Crozier and Glade, 2012; Bobrowsky and Couture, 2014; Jaboyedoff et al., 2016). Perhaps the most exciting part of the demonstration has been the visualisation of the very initial signs of deformation that appear before the full landslide develops (Figure 6-6, Step 1(a) and (b). These arise due to movement along the surface slip, and are manifest as minor cracks across the ground (Varnes, 1978), mainly on the upper ridge and at the bottom of the model's slope surface. The incremental development of these changes (Figure 6-6, Steps 2, 3 and 4) was an example of how the deformation begins and progresses over time, something that was otherwise not easily understood. As a result, participants were able to comprehend how apparently minor cracks on the surface could relate to a wider-scale landslide, enabling them to start thinking about forecasting 'where' movements might occur next and 'when' they might occur.

Although the newly initiated deformations were eye-catching and exciting to observe, another key factor in the self-assessment of landslide hazards that was explored with the demonstrator was historical or apparently inactive landslides. These landslides, especially those located around the 'village' settlements, are seated on old rotational deposits that might reactivate or change in the future (Maes et al., 2017). The reactivation of ancient landslides may pose new threats, which is a very important component in predicting future risks and the protection measures required (Calvello, 2017). Critically, the model was able to show that landslides can start and then stop; therefore, one that appears dormant is not necessarily going to remain stable in the future. It may also be the case that communities have ignored such underlying hazards due to a lack of historical or wider knowledge of the area. Although the demonstrator did not consider historical landslides, a more explicit presentation of how old landslides can behave could easily be developed further.

The demonstrator included several different features associated with landslides. The local landscape was replicated in the model; however, several features are absent due to limitations as to what can be reproduced. Despite this, the features actually on the model appeared quite familiar to most participants, and some remarked that the model demonstrated the features 'very well', including those that seem to appear or disappear over time. For example, one of the participants wrote as follows:

> The model demonstration was very useful in conveying a specific type of landslide mechanism (slide) like the landslide in Yarsa VDC Rasuwa district (Thangdor). It showed us warning signs of landslides like – long cracks developed at the top of landslides; the tilting of electric or telephone poles; inclination of trees from normal position, etc. It shows that people living in places far away from cracks might be vulnerable as well, and highlights importance of careful observations from local community to monitor landslides, so the model is very useful.

Respondent 5, QT#5, Chaku (response from participants)

The community demonstrations also showed that at least to some extent, and partly based on the materials used, each run might not generate exactly the same features as previous deployments, for example, the ground failure patterns and cracking; this may include the location of the initiation of the cracking in each demonstration (see Figure 6-6). Despite these discrepancies, the deployments did not differ from one another fundamentally, and the apparent consistency in results proved immensely useful. The demonstrator was designed to consider only a relatively homogenous lithology overlaying a distinct layer of bedrock (e.g. cross-section view in Figure 6-7(a)). The clear Perspex sides of the model also generated significant interest from participants in that they allowed the sub-surface to be seen, importantly, relating it to features on the surface.

One of the intentions of the demonstrator was to make a clearer distinction between hazard and exposure. The controls on each of these factors, including land use, risk management practices, local knowledge and past experiences, all have an important role in both reducing and increasing risk (Petley et al., 2007; Oven, 2009; Lennartz, 2013; Chaturvedi et al., 2018). In this regard, a wide range of features (Figure 6-5) was placed on the surface of the model, for example, the alignment of rural roads. The instability that these features generated on the model's surface was useful and, interestingly, replicated real-world instabilities that were commonly observed (Michoud et al., 2013). The ability to position features and to predict the approximate location of cracks as they evolved meant that it was relatively easy to delineate features in the model representing the hazard, exposure and resultant risk.

Building a 3D model that represented the entire landscape to demonstrate a synoptic view of the full landslide process was challenging, but was one of the main goals of the research. A significant point about the demonstrator was that it replicated evolving landslide features at the whole landscape scale, particularly in a context in which householders had previously only reported a relatively localised knowledge of landslide hazards and risks. As such, an individual householder may only observe and, therefore, be aware of very local features, rather than having a wider view of the area, which may include a far larger landslide sitting beneath the settlement. This local view is potentially sustained by the apparently limited communication and exchange of information between communities, which the model sought to highlight. Very few participants were able to describe what was happening beyond their village, and there was almost no evidence of knowledge about potential landslides beyond the visible terrain.

A critical challenge posed by the nature of landslides is their often apparently episodic nature. As a result, a landslide may remain apparently dormant for many months, with features on the surface remaining unchanged or being lost. As a result of this, it is difficult to explain how landslides change over time and why, and how this relates to sub-surface features. As a result, explaining the value of locally appropriate mitigation measures, such as bioengineering (Devkota et al., 2014), can also be challenging when someone who has never witnessed landslide change in action can find it difficult to imagine how this can happen. For example, community-based monitoring can be used as a means of risk mitigation for many natural hazards (Wilderman et al., 2004; Dickinson et al., 2012; Stone et al., 2014); however, for landslides that can be highly seasonal, the value of monitoring is often difficult to explain. The changes in the demonstrator's modelled landslide offer an opportunity for the audience to visualise these processes at first hand and, hence, to appreciate more fully the potential value of simple monitoring. Therefore, monitoring could be a significant local contribution to establishing a local early warning system and to reducing risks (Michoud et al., 2013; Thapa and Adhikari, 2019). Various techniques based on different approaches are available for monitoring landslides, for example, peg monitoring (Amatya, 2020), and these can very easily be demonstrated at scale on the model using locally improvised materials.

The demonstration led to an open discussion of local issues on numerous occasions, and these often focused on the daily challenges participants faced and were able to explain through the features shown on the model. The key observations included references to locally experienced phenomena, often triggered by associating features on the model with features in the landscape. This tended to prompt discussions between audience members (Figure 6-9) and, in general, added a great deal of clarity to the quality of information that was being offered by participants (Pidgeon, 1998; Stewart and Lewis, 2017). For example, significant discussion was generated in relation to old apparently dormant landslides, crucially, that they could reactivate or fail in the future. One of the participants also highlighted that the 'signs of old landslides might have disappeared over time because of both natural processes and human activities such as farming, road construction and so on', but during the demonstration recognised that the underlying risks may still persist.

This issue was often raised by participants, who recalled previous features of landslides around the village that had since disappeared. One participant mentioned that a village close to Marming had been lost about 70 years ago, citing the importance of paying close attention to landslide warning signs as shown in the model, even if these became less visible over time. Another participant mentioned that ignoring (warning) signs was commonplace among villagers. The model was valuable in showing the link between the surface features and the movement of the wider landslide mass, and the development of the landslide features underground, and attempted to tackle this by displaying the inner features of the slope through the Perspex (transparent) sides. As such, the model was considered helpful in explaining why such features still represent a risk even if they are invisible on the surface. Participants highlighted the value they saw in the modelling approach:

> First of all, I liked this model very well. Because everywhere we [spoke] about this [natural] disaster. [But] it was just a matter of hearing [listen from them], [instead] currently you showed it to us with explanation [you explained it]. It also gave us more insight into the effects [of landslides], ways to minimise [its impacts] it and how to look after it. Because what we saw in it will never be forgotten. It gives people more knowledge, so you can go to other schools, toles, neighbourhoods, villages, and tell them which will have a direct impact on them [which you did for us here]. This is how society can change itself. And, I will be trying my best to help you again.
>
> Respondent 2 (Chaku, written response)

6.5.2 Demonstration and presentation of risk reduction messages for landslides

Most risk communication messages have been designed or developed for large-scale, low-frequency, rapid-onset, high-impact risk events (e.g. earthquakes, volcanoes, floods of high magnitude) using different kinds of tools (Haynes et al., 2007; Sanquini et al., 2016a, 2016b; Hicks et al., 2017; Bretton et al., 2018). These kinds of events are often referred to as 'intensive risks' (UN, 2009; UNISDR, 2009) and, typically, receive significant attention in risk communication studies. In recent years, smaller-scale everyday hazards (Oven, 2009), which are referred to as 'extensive risks' (UNISDR, 2009), have received increasing attention, because such extensive events result in a significant cumulative impact at individual, household or community level (UNDP, 2009; UNISDR, 2009; DesInventar Nepal, 2017). Landslide risks in rural Nepal fall into this category because they are mostly small in magnitude and pervasive in occurrence. Therefore, the messages with regard to risk reduction for landslides that were delivered in the demonstrations were focused on this type of hazard.

The key messages were developed to focus on risks that affect local people's everyday lives, and covered landslide hazards, risk, common misunderstandings and the potential role of the community in local landslide risk reduction initiatives (as outlined in Table 6-1). In general, the model was deemed to have effectively displayed the message 'that the various risky places could be mitigated by finding alternatives by communities to such risky problems and avoiding them. Through this, we can raise awareness of such problems of landslide risk areas'. (Respondent 3, in Chaku). A significant observation from the use of the demonstrator was a need to recognise the role of local langauge. Experience with discussing the features on the model showed that there were rarely direct translations or categorisations that equated with more scientific notation. The language used included definitions, commonly used terms and ways of explaining the characteristics of features. Communicating information on hazards and risks using a consistent definition of terms by both local communities and experts was a foreseeable challenge. These difficulties were minimised with the use of commonly used terms. An example noted during demonstrations was the use of the term *baadhi बाढी*, the translation of which is the condition of 'flood', either via inundation (pluvial) or flash floods (hyper-concentrated flows), or even debris flows. For instance, people always referred to *baadhi* in the Chhyadi Khola, but these floods were more formally described as debris flows because their source was landslides and they were comprised of a dense mix of liquids and solids common to debris flows. Although debris flows are not how floods are commonly understood, it was noted that *baadhi* was used as a general term to mean debris flows. This shows that the same terms are used differently, and often very locally, and that the descriptions of individual locations vary between villages, reflecting what can be quite different contexts. It is necessary to include the potential for a wide variety of explanations in any communication concerning landslide risk, because this is crucial for understanding these contextual meanings of hazards and risks. For example, the use of *baadhi* in the hills of Nepal and in Terai might be understood differently, but may also vary even between valley bottom settlements and those settlements along tributaries or *thado-khola* streams (those with a very steep profile), for example, Chhyadi.

Similarly, participants often made their own categorisations of landslides and their features that were commonly based more on a perceived future potential impact or event size. For instance, it was common among villagers to use the most direct translation of 'landslides' to refer to larger and faster movements of rock and soil. High-magnitude hazard events such as the Jure landslide attract greater attention, and appeared to shape many of the local people's concerns, in particular, the possibility of a similar event happening in their own locality (Oven and Rigg, 2015; Oven et al., 2021). Therefore, in part, the collective impact of the demonstrator has been to raise awareness and promote a more detailed knowledge of landslides and the hazards and risks they pose. Ultimately, the intention of this is to facilitate discussion, thereby enabling more informed decision-making. Any future use of the demonstrator in which the aim is some form of knowledge exchange must take these concepts and vocabularies into account.

Figure 6-9. Community demonstration and discussion (interaction between participants and demonstrator). (Above) in Chaku, an open site, and (below) The Last Resort hotel (closed premises) (2019).

The demonstrations were conducted in the areas heavily affected by the 2015 GE, and many settlements near to the demonstration locations had been recommended for relocation, as per the GHA (NRA, 2017a, 2017b). In these locations, participants raised concerns in relation to how landslides nearby might behave in the future. For example, several participants were aware of the situation in Lampate (Category 3 settlement, to be relocated), which had a landslide perched above it. The former ward chair raised several of these questions, and in doing so used features shown on the model to illustrate his point, particularly commenting that the way they changed helped to explain his meaning. He suggested that the model could be useful in demonstrating the importance of relocation to people for whom it had been recommended. Importantly, in such settings, the demonstrator was designed not to scare people, but to help make them aware of the potential situation and how it might evolve.

A key message presented was that not all landslides or areas near to landslides are equally hazardous, both in space and over time. During the demonstrations, it was emphasised that landslides were not uniformly distributed across the landscape, highlighting the value of mapping out the locations known to be at greater levels of risk (Figure 6-2 and Figure 6-3). Although the model was not built to represent a specific location, the representation of typical local hazards and risks appeared successful. For example, participants identified locations on the modelled landscape as similar to their own, as shown by a villager in Marming (c. 40 yr./male), who drew a parallel with his own house ('this is the place, where my house is'), and then went on to express his concerns about the need to relocate after the 2015 GE. The same participant had several queries about potential safer locations and, specifically, what signs to look out for that might indicate a safer place to build a new house. This example shows that live demonstrators can significantly help people to recognise and think more precisely about the local landslide hazards and risks. In this sense, the demonstration has opened up discussions about the local issues and context, as found in Oven et al. (2021). Essentially, such discussions enable people to explore, question and challenge their own knowledge and situated understandings.

The demonstrator provides the opportunity to promote participants' self-assessment of hazards and risks. Combining their own experiences with the future possibilities of how landslides might change can enhance anticipation of the future impact, for example, an increase or decrease in the likelihood of future landslide changes (Lujala et al., 2015). During the demonstrations, mitigation options were explored with a focus on the potential of simple low-tech monitoring of landslides using stakes that could be implemented by communities themselves. This approach was incorporated within the demonstration at scale using the model, and the incremental deformation clearly demonstrated how movement could be measured using stakes. One of the participants, who saw further similar possibilities, appreciated this example:

> The model looks great. On which we found our settings are represented very much like living things [realistic]. Model performance has conveyed that prevention is better before the start and loss due to landslides can be avoided by taking preventative and alternative measures without fearful consequences. The ground breaking in the model has been an impressive display of the model by presenters along with the valuable information conveyed throughout the time, as well as the interaction between the people [presenters, experts] and the community [members] made the [interaction] interesting.
>
> Respondent 1 (teacher in Chaku from Marming, written)

6.5.3 A tool for raising awareness, and for advocacy and knowledge exchange

As a tool, the demonstrator sought to facilitate understanding of how landslide hazards can translate into risk for local householders or communities. The experience gained from the PMEs (in Chapter 5) illustrated that understandings of the hazards and risks can be better articulated when working with true-colour satellite images and photographs. Previous research also suggests that a 3D view often offers a format that participants can relate to better when marking hazard and risk elements on a mapped representation of their landscape (Rambaldi, 2010; Gaillard et al., 2013). The layering of information on the dynamic surface of the 3D landslide model, particularly that which described the locations of features of interest such as houses, appeared to help participants engage with the model.

The discussion that developed in response to the demonstration, together with the narratives shared by the participants, was able to bridge people's different perspectives, often highlighting apparent mismatches between definitions or interpretations of what people observe in their location. One important observation was the degree to which participants viewed the demonstration as being appropriate for them. A common reaction, particularly from officials, was that it was a tool for schoolchildren, and perhaps not for people in their position, despite this not being the intention. This partly relates to the simplified design of the model, which had been necessary, but also shows the continued challenge of being able to convey important message to people in these positions who are also commonly the decision-makers with regard to risk reduction.

Participants shared reflections on traditional practices for managing landslides, and on some mitigation or preparedness activities. In general, this suggested a historically more effective and locally implemented range of techniques for controlling landslides and reducing the consequences during the time of heavy rainfall. Again, these examples were best described when linked to the features replicated on the model, for example, by pointing at locations where mitigation measures of this type for protecting houses and farmlands (*khetbari*) could be positioned, for example, *barsheni bhal-kataune बर्षेनी भल-कटाउने* (yearly routine monsoon runoff channelling) and *bhal-niyantran भल नियन्त्रण* (runoff, drainage control). In Ghunsa (a *tole* in Marming), participants noted these practices for the maintenance of local roads in pre- and post-monsoon periods, and that they were led by local champions (village, social leaders). The pre-monsoon activity of *bhal-kataune* (channelling runoff) used to be undertaken before the monsoon started at *makai godne bela मकै गोड्नेबेला* (maize crop weeding time) in *Jeth* (May–June), according to the agricultural calendar. The post-monsoon activities mainly consisted of maintaining walking trails just before the Dahshain festival in *Ashwin* (September–October), when footfall was commonly much higher as people returned to their natal villages.

Other examples described included the annual maintenance of small channel networks that focus on channelling rainwater along the contours (*bhal-kataune*). This is often undertaken (Figure 5-18) where the soils are fragile (Upadhya, 2009). Similarly, *bhal-kulo* or *kuleso-katne भलकुलो, कुलेसो काट्ने, पानी तर्काउने*, similar to *bhal-kataune*, is controlled draining from each house roof or house yard, and from the walking trails, ensuring that rainwater is diverted efficiently. This activity signifies the value householders place on such controls, and their role in reducing risks to an individual's property. Although the model did not directly show the role of surface water, it was able to help to explain why minimising the ingress of water was important for reducing wider slope instability. Despite such limitations, the demonstration experience provided participants with the opportunity to identify the location of appropriate mitigation measures.

Participants offered their own explanations and definitions for events and land features as seen both in the model and in the local landscape. This included what was described as a 'landslide' (*pahiro पहिरो*), a feature with the potential to have a large effect on a community. As such, this revealed participants' wider focus on what were considered to be bigger events, which they assumed to be associated with a higher degree of hazard and risk, indicating more widely observed perceptions of risk (Slovic and Weber, 2002). At first, during the demonstrations, participants did not mention or were not drawn to the small-scale and slow-moving events, despite these being more commonplace in conversation. This perhaps reflects the common distinction that is commonly made between 'tremors' (small earthquakes), and large earthquakes, such as that experienced in 2015. Locally, the two are rarely described as being just two different scales of the same phenomena.

In relation to the above, one message highlighted in the demonstrator trials was the idea that the smaller events in total can have a larger net impact on individual households, as well as generating disruption to local walking trails and causing the loss of farmland. Similarly, when exploring how landslides evolved, the demonstrator was able to show how smaller events progressively become larger and, therefore, unmanageable for both households and communities.

6.5.4 Guidelines and protocols for future use

Risk communication in relation to landslide hazards and risks remains in its infancy, compared with that for other hazards and risks (Haynes et al., 2007; Wagner, 2007; Mitchell et al., 2008; Kellens et al., 2013; Sanquini et al., 2016a; Klonner et al., 2018). The demonstrator was designed to help address this need by conducting participatory, live demonstrations that drew directly on participants' own personal experience (Chaturvedi et al., 2017, p. 241). The approach is also heavily focused on visualising risks in that it replicates the processes of landslide failure in a memorable fashion. The discussion of the demonstrator also allowed the identification of ways in which the model and its presentation could be improved.

The experience of developing the demonstrator suggests that when it is tailored to the context of the middle hills region of Nepal by depicting features such as rural roads and widely distributed housing, it helps to link participants' observations to the progression of slope (in)stability as landslides develop. Moreover, the community demonstration enabled me not only to understand the local priorities, but also to find out more about the audience's interest in landslides and the risks they pose. In addition, I was able to assess the uptake and comprehension of the key messages, the aim of which was to focus on those hazards and risks that pose the greatest danger to communities.

6.5.5 Evaluation: review of the 'success' of the process

Assessing the 'evidence' of the successes of the landslide demonstrator is challenging given the early stage of this research. The preliminary evaluation of the risk communication is a key element for improving efficacy for future purposes (Niewöhner et al., 2004). In this research, I made various assessments at different stages bringing in the participant's own views, which can be related within the simple framework of monitoring, evaluation, and learning (MEL) (Cassidy and Ball, 2018). MEL in the present research has been outlined within the context of formal and informal responses but given time constraints this has been limited to anecdotal evidence collected during the demonstrations in response to both formal questions (written and audio/video records) as well as from the interactive discussions held during the demonstrations themselves (see Appendix-9 and Appendix 10). This has been an important dimension in evaluating the effectiveness of the demonstrator in terms of the demonstration process itself, the comprehensiveness of the messages conveyed, and the degree to which the model achieves the aim of increasing awareness of the participants. A key part of this was my evaluation on 'what works, what does not, when and for whom' for instance (Cassidy and Ball 2018). In this regard, in this thesis I have identified clear evidence of success based upon the responses from the audience which falls broadly into the following categories: (a) the reach, (b) the quality and usefulness of the tool, and (c) uptake and use (Cassidy and Ball, 2018) . My evaluation is focused upon the scope of the research presented in this thesis, and with respect to the future strategy for assessing the success of this approach.

Within the scope of this thesis, the following observations were be made under three key themes. These observations have been derived from the participant's responses in the form of written and verbal quotations, transcriptions from audio and video records, dialogues, and observations as a researcher (Appendix 9 and Appendix 10). Sequentially, I summarise these below:

> Firstly, in terms of reach, or in other words the quantity and breadth of the communication activity (Cassidy and Ball, 2018) to the target audience, this work gained a significant achievement in accessing the target community members. The evidence of active participation of local communities was clear, as evidenced through active engagement during the demos. This forms a baseline for broader comparison in the future. Moreover, the interest shown during the demonstration specifically in schools and amongst community members, with the approach being highly praised and clearly appreciated by local communities, local authority's representatives, and other key stakeholders which are encouraging for future improved implementation. A particular feature was the recognition by participants in the effort needed to produce, and then run the model in their community.
>
> Secondly, the utility and quality of the demonstration have been evidenced again by the active engagement of participants during the events. Feedback reflected the apparent

usefulness of the messages to household decisions, with many viewing the information provided as both credible, reputable, authoritative and trustworthy (Cassidy and Ball, 2018). The dialogue during the events indicated the participant's expectations around upscaling in terms of the roll out of demonstrations, but also in creating demand for extending the scope of the demonstrations for more complex or other hazards. This can be a valid indicator for the utility of the approach and in particular the focus on local needs.

Finally, the uptake and use of the outputs of the demo, or their acceptance amongst participants (Alcántara-Ayala et al., 2004), implies the potential to replicate both the model 'demonstrator' and the 'demonstration' with the lessons learned here. The future uptake will be best shaped by the inclusion of the synthesized feedback from the demosntrations conducted to date (Drew et al., 2003), ensuring that the evaluation will enhance the approach and increase the acceptance of this with target communities (González et al., 2014). The future uptake from this learning is already being upscaled in communities through the EU ECHO-funded 'Pratibaddha' project, a collaborative effort of Durham University, National Society for Earthquake Technology – Nepal, and People in Need (DU/NSET/PIN). The structured evaluation process followed by this initiative will form the basis for a more formal evaluation, which has otherwise not been possible within the confines of this thesis.

The feedback collected from a range of stakeholders in the process, including municipal officials, experts, local representatives, teachers and others add great value for further improve of the demonstrator and demonstration (Drew et al., 2003; Alcántara-Ayala et al., 2004; Niewöhner et al., 2004; Haynes et al., 2007; González et al., 2014). The recommendations for the future improvement of the approach and the first steps towards a continuous review to enable me to address the question of 'how effective is the demonstration and how this can be assessed through time?' are now considered. I have proposed a way forward in following sections (section 6.6) on the wider uptake of the model, the demonstrator and the demonstration and their evaluation. The MEL approach for this is comprehensive feedback collected using a simple structured survey distributed among participants and other users. For instance, a 'pre-and-post survey' can be implemented to collect feedback from the audiencs, for instance, before and after the demonstration. This approach has been applied widely in many other training programs (such as the PEER program of NSET) and could be equally valuable for the present case. Moreover, interviews, internal feedback logs, case studies, or stories of changes achieved could be additional practical parts of a fuller evaluation (Hicks et al., 2017).

6.5.6 Conclusions

My conclusions with regard to this research include both (a) a general reflection on model performance and an evaluation of the approach, and (b) lessons for the future development of the technique. The findings are based on the field demonstration and the main outcomes, and the lessons learned in the process. The latter also provide general guidance for further research and for upscaling and replicating the demonstration.

The new tool for demonstrating landslide processes, which uses local soil and vegetation and miniature figures to represent features, has been based on a model hillslope akin to those prevalent in Nepal's hills and mountains. The model represents a part of a hill slope with vegetation, drainage and community assets such as houses. A plastic sheet is hidden underneath the 'vegetation', and the slope is made to fail by a roller mechanism. The roller pulls the plastic sheet, dragging the soil on the slope and triggering slope movement; this simulates the natural slope movement, thereby showing how landslide hazards evolve, progress and then translate into the spatial–temporal context of risk at the local (village) level. The demonstrator was developed based on three principal elements: the need for a visually attractive 3D model; the need to encourage discission; and the need to reach a consensus by incorporating local understandings of hazard and risk. The successful implementation of the demonstration suggests that this innovative approach, which draws on ideas from participatory modelling in DRR, can inform landslide awareness and risk assessment at the local level.

Live demonstrations were found to be a promising way of improving existing risk communication in relation to landsliding. The personal experience of participants and the visibility of a similar scenario in the demonstration were seen to inspire discussion about the community's concerns with regard to landslides. The experience from both the trials and the community demonstrations strongly suggests this approach has the potential to engage different types of audience. In all deployments of the demonstration, the participants made links between their own environment and the corresponding similarities in the model, and observations quickly extended to a discussion in which they sought answers to local landslide problems. Such open discussion about a collective problem such as landslides is not commonplace in rural villages; however, building a consensus about the risks faced in this manner may be a useful step towards a more organised and effective advocacy to government for assistance with these problems. Hence, it can be considered that the demonstrator platform provides a good opportunity for experts and the public to exchange understandings about local conditions, clarify misconceptions, learn from each other and form a consensus with regard to decision-making. Such active engagement was a source of inspiration for myself and those involved in running the demonstration, and we were also impressed by the often insightful and probing questions from the participants during and after it.

Lessons from the household survey and PMEs suggested a need to understand landslide hazards in the wider landscape, this lack of understanding being one of the key gaps in local knowledge. Therefore, a holistic view of 'the beyond visible sphere' of the householder was important (Niewöhner et al., 2004; Sullivan-Wiley and Gianotti, 2017; Cuomo, 2020). The demonstrator tries to provide a way of illustrating both large and small events, the latter being commonly ignored or neglected (Sudmeier-Rieux et al., 2013). Hence, an important further aim of the demonstration was to add a temporal dimension to the understanding of landslide risk, illustrated by the changing nature of landslide hazards and risks as shown on the model's surface. This was intended to help people understand how landslides changed, and to identify key indicators of possible future movements. It became evident from the discussion that the addition of the time element was perhaps the most interesting and enlightening part of the model; as such, it counters some of the criticism of the static nature of other resources, for example, hazard maps.

6.6 Next steps

Although the progress made with the development of the demonstrator is only the first step in the process of developing a new method for communicating information on landslide hazards and risks, the approach has showed promise. It remains too early to conclude the complete set of recommendations on the model's effectiveness, but it is hoped that this work will make a significant contribution to the future improvement of both the physical aspects of the model and the delivery of messages in the demonstration. Based on lessons learned, I propose the following next steps to develop this approach further:

1. The detail on the model matters. Recognising key features and being able to associate them with those in the local villages was a vital part of enabling participants to make links between what was shown in the model and what they experienced locally. A large-scale model covering a wide spatial extent of a valley may further enhance this ability to make connections.
2. Detailed protocols should be developed based on lessons learned in the initial deployment of the demonstrator. The current guidelines should be expanded and given in detail for both the fabrication and assembly of the model, and the messages to be delivered. The contribution of multi-disciplinary expertise from geographers, geologists, engineers, social workers, local authorities and community members will considerably improve the design of both the technical and socio-cultural aspects of the technique. It is also possible that more dedicated or specifically focused deployments of the model could be helpful, for example, a session dedicated to the impact of rural road construction, or to the installation of monitoring systems.
3. To meet local demand from schools, local authorities and communities themselves, there is a need to develop tailored educational materials for different target groups. In addition, to aid the upscaling of the approach to these groups, the demonstration could be integrated into

online/video materials for wider distribution, although care would be needed to ensure that such approaches remained engaging.

4. To continue to develop the take-home messages, a next step would be to develop tangible ‘simple rules’, or answers to ‘frequently asked questions’, again, potentially, according to target audience. This is important to promote sustained engagement in the issues raised by the demonstrator after the live demonstration has finished.
5. In collaboration with local authorities, explore the potential for integrating the models into the local education curricula.
6. Collaborate with a wider group of stakeholders to explore ways of integrating the approach into DRR management planning at the local level.
7. Establish a clearer monitoring, evaluation and learning (MEL) strategy.

The trials with the demonstrator have provided a clear research direction for the future improvement of the model in several aspects. I end this chapter with a set of suggestions for future research that will focus on the improvement of the model itself:

1. Explore ways to enhance the 3D representation of local topography in the model, in addition to adding a more realistic representation of the conditions that trigger landslides. At present, the model does not consider the rainfall input as a trigger factor, but this could be simulated with a spray, or similar. The model could be adapted in this manner to show the significance of rainfall intensity duration thresholds for triggering landslide failure.
2. At present, the sub-surface behaviour or internal structure is highly simplified. This could be enhanced to show the specifics of different soil depths, materials and behaviours such as saturation in more detail. Such enhancement could allow a more tangible link between landslides and their trigger mechanisms, which is an important concept to grasp when explaining early warning systems – how they work and their problems.
3. The role of the modification of the surface in triggering landslides is currently not well represented in the model; however, it is widely understood that the construction of rural roads is a critical part of landslide risk in rural Nepal at present. Consideration should be given to including both natural and man-made surface structures, anthropogenic controls such as walls, and structural and non-structural elements, so that input from different scenarios can be obtained.
4. A key benefit could be to increase the overall size of the model. Potentially, this would allow sufficient stress to be generated to allow the modelled surface to fail under its own weight,

while also increasing its ability to represent a wide geographical area, and to add realism to the features positioned on the surface.

Chapter 7

Discussion and conclusion

7.1 Introduction

This chapter discusses the findings from the research presented in this thesis and then draws out the conclusions. It progressively develops links between the results obtained in Chapters 4, 5 and 6, and is split into three separate sections that discuss the aim, the research and the findings in relation to the following: household understandings of landslide hazards and risks (Chapter 4); the PMEs (Chapter 5); and the development and implementation of a physical model, that is, the landslide demonstrator, for communicating landslide hazards and risks (Chapter 6). The links between these three elements are explored in the following sections, in which I focus specifically on the implications for everyday landslide hazards and risks in Nepal. In so doing, the less extreme, smaller-scale and slow-onset landslides that often affect communities' everyday lives in Nepal's mountain areas are highlighted. Therefore, this chapter aims to conclude by referring back to the aim of the research and original research questions as follows:

1. How do householders perceive and respond to landslides following the 2015 GE?
2. How has the perception and understanding of landslide hazards and risks changed over time?
3. What knowledge and capacity do communities have with regard to the management of landslide hazards and risks?
4. How and to what extent do different forms of risk communication support communities to broaden their understanding of landslide hazards and risks with the aim of increasing resilience to landslides?

7.2 Household understandings of landslide hazards and risks

The high-magnitude landslide events at Nagpuje and Lidi in Sindhupalchok District during the 2020 monsoon (Rosser et al., 2021) received significant attention from the federal authorities in Nepal.

After the Jure landslide in 2014, these two events in Sindhupalchok resulted in the highest number of fatalities and loss of property, causing the local government to call for urgent support for both immediate action and raising awareness. In addition to high-magnitude landslide events, which occur less often, hundreds of additional smaller-impact landslides collectively cause significant annual losses every year, both human lives and property. Such ongoing losses show there is a need for greater individual and community awareness with regard to landslide hazards and risks to support decision-making in relation to LRM. In line with Priority 1 of the SDGs (UNISDR, 2015; Rahman and Fang, 2019), assessing local understandings of these hazards and risks has been one of the main objectives of this research.

The household survey aimed to document how householders perceive and prioritise landslide hazards and risks in their everyday life, and to capture the impact on their day-to-day existence. The conclusions below are based on the results of this survey, which reflected people's judgements of hazard and risk as related to everyday decision-making (Landeros-Mugica et al., 2016; Gravina et al., 2017). The survey was conducted in four communities from two typical and distinct geographical and economic settings: on-road and off-road. The household understandings discussed above include views on the following: the physical nature of local landslides (e.g. the characteristics of landslides as understood by householders, that is, their distribution, size and frequency); how landslide risk changes (e.g. what people believe to be the main causes and trigger factors, how they understand the evolving nature of landslides); and the impact that landslides have and how this is managed (e.g. impact on lives and livelihoods, local risk management strategies).

7.2.1 Understandings of landslide hazards and risks

Below, I summarise the key themes that have emerged from the household survey in the UBK. The survey results show that community members were able to identify multiple landslide locations close to their houses, farmland and areas in which day-to-day activities were conducted. Such mental inventories come from householders' close familiarity with the local landscape, for which they were clearly able to recall observations of detailed environmental changes both from a positive or negative perspective (Zhang et al., 2010; Lujala et al., 2015). Householders' knowledge about the location of problematic landslides was often found to be directly related to concerns associated with everyday life: obstruction of walking trails and the local road, notably when this led to having to change regular travel routes (e.g. routes to farmland, visits to forests for fodder collection, safe passage for grazing cattle); and access to schools, health centres and other community facilities. When the data were analysed, it was clear that householders' attention was focused on places close to their settlement as opposed to more distant locations, which is perhaps not surprising.

Respondents were able to describe landslide locations in considerable depth, but often related this information to experience of previous losses associated with noteworthy earlier events, as is common for recall of other hazards (Edgar and Jackson, 1981; Grothmann and Reusswig, 2006; Wagner, 2007). This local focus and the apparent limited sphere of householder knowledge combined with previous experience also reflects wider observations of similar patterns in relation to the influence of perceived threats (Wachinger and Renn, 2010; Zhang et al., 2010; Wachinger et al., 2013; Lujala et al., 2015). The seemingly local focus was commonly centred on respondents' own surroundings and those of their immediate neighbours and the wider village, which was echoed by a suggestion that their own village was facing a higher threat in comparison with others in the surrounding valley.

Responses varied considerably with regard to understandings of the underlying physical mechanisms that lead to landslides: the role of *ground conditions* or the *nature of earth materials*, in this case, what was commonly referred to as 'weak soil'; the role of *topography*; and knowledge about *fragile locations*, which are often associated with lasting damage from the 2015 GE. If the responses are evaluated in terms of either (a) internal or (b) external factors (Devkota et al., 2014; Jaboyedoff et al., 2016), which, typically, reflects how respondents categorise their understandings of what controls the landslides, it was notable that very few people directly or indirectly referred to any form of sub-surface ground condition as playing a role in a slope's instability. After exploring this further, this was either unknown to them, or just referred to in very general terms as 'what lies beneath us!' A geological perspective was often absent despite the visible surface signs of landslides, for example, cracks, these being a commonly cited factor indicating an area perceived to be under threat from landslides. Wider research has observed a similar lack of knowledge about sub-surface or ground conditions, but the lack of even very basic geological knowledge is also known to influence significantly the success of efforts to mitigate landslides at the community level (Jaboyedoff et al., 2016; Gravina et al., 2017). It has been argued that such knowledge, even in a basic form, is important in identifying areas at risk that could, potentially, put lives and property in danger (Milledge et al., 2018, 2019), and in enabling people to clarify apparent misconceptions about the direct or indirect controls on landslide hazards and how to manage them. This further emphasises the need to include basic hazard and risk science in secondary school curricula to help strengthen geological knowledge from an early age.

Direct or indirect experience of previous landslides was found to be a key factor in understanding the potential for future landslide risks. Similar to Gravina et al. (2017), who found that direct hazard experience plays an important role in any household's risk awareness, in the UBK, over 90% of householders said the 2015 GE and subsequent landsliding had been affecting their homes primarily through increasing exposure to landslides. In my survey, and as observed elsewhere, house location might have the most decisive influence on perceived current risk, and on understandings of future risk (Wachinger and Renn, 2010; Wachinger et al., 2013). Very similar to these observations (Wachinger and Renn, 2010; Wachinger et al., 2013), respondents were highly aware of the potential impact landslides could have on their homes, farmland, walking trails and roads. Furthermore, it was clear that the impact of higher-magnitude events was more commonly reported than that of smaller-sized events, and that these larger events essentially dominated the perceived future threat to households (Wachinger and Renn, 2010; Wachinger et al., 2013). For example, the Jure landslide of 2014, which occurred some *c.*20 km downstream from the field site, and the devastating impact of the 2015 GE, were both commonly referred to by respondents and so considerably shaped understandings of risk. Such examples of high-magnitude events, or recent memories of these events, are given higher priority when respondents are describing their own mental picture of landslide risks in the UBK (Niewöhner et al., 2004; Wagner, 2007).

The *direct impact of landslides* on households in Listi and Marming (both off-road), was reflected in responses from subsistence farmers who articulated concerns about losing their *ghar-khet* (house and farmland, a common Nepali term, which here was used to describe losing everything needed for sustaining a livelihood). Conversely, in Larcha and Hindi (both on-road), householders worried about losing their homes and their livelihoods (shops), the continued hindrance of roadblocks due to landslides and the continued closure of the border with Tibet. There was considerable variability in responses in both settings, illustrating that perceptions of risk might differ between the individual and the community (village) (Wachinger et al., 2013), or according to income stream. For instance, in a personal communication, a resident in Chhyadi (c. 40 yrs./f) said: 'rich people have their house in Kathmandu, but we have nothing other than here, have to live here at any cost', which clearly illustrates that perceptions of risk are strongly related to the economic and social choices available for avoiding hazards in potentially dangerous places (Alexander, 1991; Sudmeier-Rieux et al., 2012).

Landslides in my UBK field sites have many forms, for example, some are rapid (debris flows), and others are slow moving, for example, creeping hillsides, and there are many other variations (Hungr et al., 2014). The most frequent response given in the household survey to the question asking how landslides were understood describes them as fast moving. Interestingly, despite living in the vicinity (e.g. in Chhyadi tole(s) , most householders did not mention slow-moving landslides located nearby, or even in the middle of the village, which may be because such events have less impact or fewer consequences for householders to consider. As far as a landslide located between Chhyadi and Sangmani, just below Pokhari, was concerned, although householders in Sangmani (a *tole* of Chhyadi village) had noted slow-moving land, respondents were more worried about instantaneous (rapid) failures coming from above them at some time in the future. Indeed, this might be a valid concern, but it also reflects an assumption that a slow-moving landslide will always be slow moving, rather than it changing behaviour at some point in the future; this may or may not be a safe assumption to make. Therefore, looking at landslides individually or by category is important for providing a more targeted understanding and may help to clarify any potential misconceptions (Paton et al., 2008; Chamlagain, 2009; Crozier and Glade, 2012; van Oort et al., 2015; Calvello et al., 2016). In such a situation, monitoring of slow-moving landslides can provide information to inform future planning, for preparing mitigation or avoidance strategies or, critically, for identifying any changes in behaviour. The practical implications of participatory local monitoring of slow-moving landslides may capture the movement, show seasonality and allow the relative risks to be assessed (Michoud et al., 2013; Hicks et al., 2017; Cieslik et al., 2019). Such innovative participatory efforts in relation to community monitoring and interpretation of this data are currently few and far between in Nepal, and could be really beneficial in years to come.

Respondents showed a good awareness of the conditions that led to landslides. One of the most common responses was about the role of *local physiography*, including topography, which was directly linked to the understanding of the potential risk posed. Similar to Wagner's (2007) findings, respondents in the UBK interpreted and broadly understood the local physical attributes that led to a greater chance of landslide hazards. A clear distinction between off-road and on-road locations with regard to the understanding of the local physiography was also apparent. The differences related to knowledge of uphill–downhill links, for example, the routes for transfer of debris as landslides run out. On-road households have very little interaction with or awareness of uphill areas where landslide sources might be located. The on-road householders' everyday activities are concerned more with roadside locations and conditions. In the on-road locations in the valley bottom, awareness of the source of landslide hazards was less than for householders who live on the hillsides. The reason behind the difference in knowledge and awareness of landslide locations may be that the off-road householders have a much greater interaction with the valley and far wider visibility across it, enabling a more extensive spatial knowledge of landslide locations. Potentially, this interaction is also related to everyday livelihood activities such as grazing of stock, farming and daily travel. Similarly, with regard to landslide trigger factors, householders recognise that these can be natural or man-made as follows, both of which are significant: (a) heavy rainfall; (b) the ongoing landslides caused by the 2015 GE; and (c) development works such as rural roads and hydroelectric power projects. Over 90% of the participants noted that rainfall aggravated these conditions in the monsoon, particularly in the years after the 2015 GE. The surface cracks observed after the earthquake and perhaps indicative of incipient landslides, were the most cited visible threats of impending landslides reported by householders, as documented elsewhere (Rosser et al., 2021). Again, local observations were found to be focused on visible signs of surface features rather than any sub-surface features or interpretation.

Among the man-made landslide trigger factors described, local road construction was most commonly cited by respondents, similar to the results drawn from several studies on unplanned local road construction in Nepal (McAdoo et al., 2018; Sudmeier-Rieux et al., 2019). The acceleration of local road construction in Nepal in recent decades, which is promoted with local government support and is intended to meet the 'increasing need for local transportation routes for communities in remote areas' (Jaboyedoff et al., 2016), has been hampered by lack of technical input (Jaboyedoff et al., 2016; Sudmeier-Rieux et al., 2019). The local roads are mainly built with unplanned *cut and fill*, creating shallow soil slides that form gullies often visible along the rural roads, and the UBK is no exception (Devkota et al., 2014; Jaboyedoff et al., 2016; Vuillez et al., 2018; Sudmeier-Rieux et al., 2019). However, the relatively smaller landslides that these processes generate, and the risks they pose, or the potential they have to grow, are rarely noted by individual householders. During community discussions, there was a high degree of concern about the perhaps cumulative problems that might arise after road construction, rather than the initial smaller-scale failures originating from the road cuts.

A common Nepali term used by communities is *pahi* (or *paik, payak parne*), which, broadly translated, means 'having to commute very often to a particular area/direction to facilities or related to livelihoods'. A key emergent feature in my research of *pahi* is the need to cross or travel near to potentially unstable areas and existing landslides. These commuting activities featured often in descriptions of landslides, and observations made during them supplemented many respondents' knowledge of at-risk locations and, hence, added a key spatial dimension to landslide hazard awareness (Gaillard et al., 2013). This can be illustrated by giving an example of how a neighbourhood perceives differences in the threat posed by two landslides of equivalent size but located in the opposite direction from one another, one having a far greater potential to have an impact on day-to-day life. The householders in Chhyadi noted the landslide at Hyangle, at the bottom of the village on the route to Chaku. This was perceived to be a greater threat, because it could block the way to Chaku, even under moderate monsoon rainfall. The Chhyadi community is far less concerned about the landslide located in the opposite direction on the way to Saptabal, which despite being only 400 m away from the first, is not considered to be problematic because only a few of the residents need to travel in this direction. As a whole, the neighbourhood/community prioritises perceived landslide hazards and risks located close to their village. Again, this illustrates that responses were very much shaped by the current visible risk, rather than the future potential for the landslide to change either in style or in the hazard that it poses. Another example, based on the same landslide between Ghunsa and Chhyadi (*toles*), showed that two adjacent communities held quite different views. Ghunsa residents made less frequent visits to Chhyadi, those they did make being for farming activities and visiting relatives, but Chhyadi residents have to travel towards Marming everyday via Ghunsa. In such a context, people's perceptions are shaped not only by proximity, but also by the spatial convenience of their everyday visits and travel.

The frequency of landslides, or how often they occur, which in part reflects how visibly active they are, was also found to influence apparent risk perception, which, in turn, is related to people's awareness of the likelihood of future events, again inferred from past experience. Respondents were able to recall the date of occurrence for most landslides readily, notably for those that predated the 2015 GE rather than those that happened afterwards. Further, householders also commonly assigned landslides to the year of occurrence or to a particular season, notably the monsoon. Distinctions were made between the following: (a) very old landslides (*dherai purano pahiro*), that is, those landslides that had existed for a long time, or at a time beyond the living memory of the respondents, or those that were described in stories passed on by parents and forefathers, such as the large and devasting Chambang landslides in Marming about 60 years ago; (b) pre-seismic landslides (*bhukampa pahileko*), that is, those landslides that existed before the 2015 GE, such as the slope failures above Lampate, which have been active for more than 20 years; (c) coseismic landslides, that is, those triggered due to the 2015 GE (*bhukampa ko karan le gayeko*), which are extensively distributed over the study area (*jata-tatai chha, hernus* (everywhere spread)); and (d) post-earthquake landslides (*bhukampa pachi ko*), which are the most recent, and are either new or reactivated events most commonly associated with the legacy of damage from the earthquake. Hence, a community's classification of landslides is based on its own timeline (Haferkorn, 2018), which may or may not be directly comparable with results shown on expert maps that are drawn using scientific inventory methods from dated satellite imagery (Kincey et al., 2020; Tian et al., 2020; Rosser et al., 2021) or any disaster database (UNDP, 2009; DesInventar Nepal, 2017; BIPAD Portal, 2021). Respondents' temporal landslide inventories can be a rich source of data, but efforts to formalise this in the context of Nepal have been very few and far between. Where landslides are small in scale and commonly remote, there is always the challenge of documenting such events in a consistent manner, but an approach using oral history and inventories may be of benefit here.

The priority of risk reduction is to focus on predicting or anticipating future hazardous events, which provides the basis for taking precautions against the hazard in the short term and, ideally, over the longer term (Wachinger and Renn, 2010). The household survey explored how respondents predict potential future losses, and over what timescale: a year; during the forthcoming monsoon; during the next five years; or any time in the future. Over 90% of respondents were certain that new landslides would have an impact on them in the next five years, but they also recognised a very high possibility of events occurring during the forthcoming monsoon. Moreover, it is clear that recognition and anticipation of the seasonality of risk is at its highest between June and September, notably with regard to the second half of the monsoon, for which there is a clear notion that greater ground or soil saturation provides optimum conditions for triggering landslides. In point of fact, in records of the average timing of landslide impact in Nepal, it is the early period of the monsoon, almost always the first month, during which the number of landslides and associated fatalities is the highest, rather than the later period (Froude and Petley, 2018). This presents an interesting paradox. A generalised conceptual diagram based on these findings (see Figure 7-1) shows how previous direct and indirect experience (for example, inferential experience or stories recounted by older people) may have influenced householders' perceptions of hazard and risk. These recollections of incidents show that according to its residents, the UBK has a high risk of landslides, signifying the importance of necessary preparations before periods such as the monsoon, when risks are high.

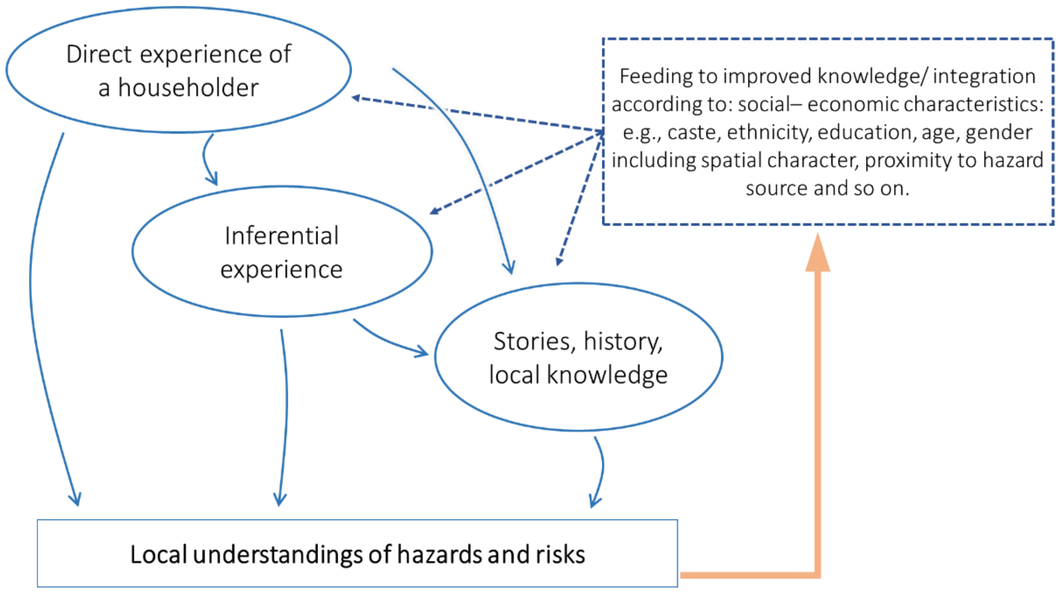


Figure 7-1. The key factors that influence local understandings of hazards and risks, especially landslide hazards and risks.

In Figure 7.1, the causal relationships are shown as the local understandings are determined by various factors based on a householder's direct or indirect previous experiences, their own assessments about local hazards and risk as part of their own inferential understandings, and the detail of local knowledge with known history, stories and lived experiences. These factors are good predictors for local communities in shaping their ideas and attitudes towards hazards and risks in the place they live (Pidgeon et al., 1992; Frewer, 2004; Ho et al., 2008). The causal connections between the factors are also influenced by the socio-economic and demographic characteristics such as their cultural traditions, social status, and place-bound factors (Lindell and Perry, 2003; Zhang et al., 2010; Wachinger et al., 2013a; Lujala et al., 2015; Roder et al., 2016). However, this study did not segregate the response based on such factors.

7.2.2 LRM at the community level

According to the new federal structure in Nepal, the local government has full responsibility for DRR and management (Bhandari et al., 2020). During my research, because this new system was in the process of being implemented, the *gaunpalika* had been formed, but at the ward level, no committees or any institutional set-up existed, leaving ward and community DRR activities to operate on an ad hoc basis. In such a context, findings were similar to those of previous studies conducted in the UBK (Oven, 2009; Oven and Rigg, 2015), whereby hazards are managed to the degree they can be by the efforts of householders or the collective community, and the focus is usually on small-scale and recurring events. In such a situation, mitigation is undertaken by pre-existing, informal community groups, for example, mothers' groups and community forest user groups, rather than formal dedicated disaster management groups (Oven, 2019).

In local landslide risk reduction, the need for a formal institutional channel of support that would enable respondents to access local authorities for assistance or help to make their collective voices heard was one of the key issues raised. For instance, householders in Chhyadi said that the construction of a hydroelectric power project located at the bottom of the village was having an impact on their homes and village in that the unregulated blasting and ground shaking was leading to the formation of cracks and, thus, potential landslides. The villagers thought the hillside was very weak compared with the other side of the valley, and they noted several active landslides in the vicinity. Similarly, in Lampate village, a Category 3 settlement according to the post-2015 GE NRA-led GHA (Oven et al., 2021), the community reported a similar problem to that in Chhyadi and Ghunsa. The respondents felt that the village was affected by landslides because of construction activities, in this case, the large-scale Madhya Bhote Koshi Hydroelectric Project, in which the end of a 15 km tunnel runs directly beneath the settlement. Again, the residents noted frequent blasting and several cracks appearing in their farmland. In both settlements, the community felt their voices were not being heard, and in cases in which there were disagreements between the locals and those who managed the hydroelectric power projects, nothing was done to resolve these. In both cases, the communities believed that an agreement on how to manage the landslide risk collectively, which they felt was necessary for these projects, could have been implemented more efficiently if a proper institutional set-up existed, for example, a disaster risk management committee. Moreover, such development projects are considered to increase exposure to landslides, both at present and in the future. Sitting alongside this are local community priorities that focus on connecting villages to other areas in the *gaunpalika* and the highway in the valley bottom, but this creates clear tensions. Because a large proportion of the *gaunpalika*'s development budget is devoted to rural access ('over 90 per cent of the *gaunpalika* development budget goes for the local road construction and yearly maintenance, reopening after monsoon' (personal communication from Ward 4 representative), other DRR priorities are 'neglected'.

Overall, based on the responses to the household survey, and similar to research conducted in a Sherpa community in the mountainous region of Nepal (Bjønness, 1986), householders in Sindhupalchok District were able to articulate a sound understanding of landslide hazards and risks in the landscape based on their local observations. Moreover, this awareness was highly influenced by the proximity of these events and their effect on daily lives and livelihoods. Therefore, some events were well known, others were not. Problematically, this means that although there are landslides that may not represent a threat at the moment, there is limited awareness of events that could evolve to be more hazardous in the future. There were also clear differences in the responses from on-road and off-road communities. The on-road communities showed limited awareness of landslide risk that lies above on the hill slopes. However, those who lived on the hillsides were more connected to the landscape and, therefore, more aware of the landslide issues that surrounded them. Throughout the household survey, it was noted particularly that people had a very limited knowledge and understanding of landslide mechanisms, in particular how these could be explained by the sub-surface soil characteristics. Although broad controls, such as steep slopes, were clearly understood, less clear was the role of rainfall or of particular soil types in causing landslides. Finally, landslide management efforts were described as reactive and coordinated only by householders or communities. A clear association was made between landsliding and development projects, notably those that involved blasting, which leads to the development of cracks. Respondents noted a lack of a formal mechanism through which their concerns could be voiced and heard. Although respondents showed a good awareness of landslide hazards and risks, apparent gaps in knowledge and capacity in the UBK were identified, and these were explored further in the PMEs described in Chapter 5.

7.3 PMEs for assessing community understandings of landslide hazards and risks

This part of my research focused on using PMEs to assess community knowledge and understandings of landslide hazards and risks in the UBK. The study relied on a mixed-methods approach (Ivankova et al., 2006; Creswell and Plano Clark, 2007) that was based on freely available maps and semi-structured group discussions, and maps co-prepared with community participants were visually analysed. The results of my PMEs showed that communities have extensive knowledge of the geography of their wider landscape, including landslides and their characteristics. One intention of the PMEs was to think about risks from landslides as a function of local views of hazard and exposure (Alexander, 1991; Halvorson and Parker Hamilton, 2010), and to consider how community knowledge could make a contribution to local landslide disaster risk initiatives. Moreover, a 'true integration' of local understandings (Oven and Rigg, 2015) and 'expert' knowledge is represented here by enabling participants to examine more formal landslide maps of the area. The PMEs were undertaken to capture how 'people draw their perception of their surroundings on a spatially referenced map' (Klonner et al., 2018, p. 2), and how they share their experiences of landslides. I also wanted to observe to what extent input from all stakeholders would benefit the mapping exercise (Pelling, 2007). Therefore, the PMEs attempted to capture community-wide understandings rather than those of individuals (Reichel and Frömming, 2014; Klonner et al., 2018).

Small groups of participants in the two case study communities of Larcha and Marming tried out the PMEs. The aerial view satellite image or 'perspective map', was a recent true-colour image freely available on Google Earth. This was the base map from which participants first identified features and then used as the surface on which they placed their own legend of symbols to highlight features or areas of concern in relation to landslides.

The PMEs were a challenge to conduct, mainly because finding sufficient time for an engaged group of participants to meet was difficult, and made more so because this part of the fieldwork was undertaken during the busy post-monsoon agricultural season, when most people are occupied in arduous farm work. As such, running the full number of PMEs, and when they did take place, maintaining participation, was challenging. The other issue was that discussions often became lively, such that far more nuance and detail occurred in the discussion rather than being captured on the maps; lively discussion is typical in rural Nepal, mapping much less so! Although the maps provided a focus for the debate, some of the most detailed findings and insights were never actually plotted. The potential effectiveness of the PMEs can be summarised in two main ways: (a) their use as a tool for assessing local understandings of landslide hazards and risks; and (b) their use for exploring knowledge integration between community members and 'experts', enabling local communities to self-assess their own landslide hazards and risks. The two are discussed in turn below.

The first aim of the PMEs was to help community participants compile *a spatial inventory of landslides*, and this formed the opening activity of the exercise. The ease with which this spatial listing of features was compiled, and the ability of participants to locate features on the satellite image, confirmed communities' geographical knowledge of the local landscape and that they were adept in positioning features spatially, albeit with a need to 'get their eye in'. Their proficiency in the PMEs confirmed the findings from the household survey in Chapter 4, providing a degree of triangulation for the research.

During the process, the expert map prepared using satellite imagery and numerical modelling (Kincey et al., 2020) was presented to participants for discussion. The aim of the exercise was to offer a forum for discussing how such expert maps can be used to complement locally held knowledge for local landslide hazard and risk assessments. In comparing these two maps, it was clear that the participants considered the satellite image map to be more convenient for identifying local features, perhaps because it was less cluttered than the expert map. The PMEs were also shown to have value in building local landslide inventories, which combined detailed knowledge of landslides and, arguably, held more locally relevant and more accurate information. As this exercise was led by community members who had been directly affected by landslides, participants' perceptions of risks, both relative and absolute, were captured very effectively in the exercise (Gaillard et al., 2013; Klonner et al., 2016, 2018).

Reflecting on the expert maps, the understanding of their usefulness was mixed among respondents. During the PMEs, these maps were shown to a variety of stakeholders ranging from local residents to teachers, and there were four broad sets of opinions on their value: (a) useful for showing risks at the local level, down to individual households; (b) useful for raising awareness of changing landslide scenarios over time and their impact; (c) useful for development planning, for example, local road construction or soil conservation; and (d) useful in providing the municipality with an overview of the location of landslide risk so people can be protected. As far as the ease with which participants could fully read and understand the expert maps was concerned, response to the PMEs was mixed. It was hard for many to comprehend the meaning of the legend, but even with only limited time, the maps did inspire a good deal of interest and showed promise as a way of collating and presenting landslide information.

The PMEs explored how landslides evolved within the study area and signified the importance of understanding the changing dynamics of landslides and the implications of this for hazards and risks. In particular, by using the colour-coded Lego, the mapping captured the recurrence of the relatively small-scale everyday landslides and how these generated hazardous conditions (see Section 7.1). The seasonal understandings of landslides described by participants mirrored the documented seasonality of landsliding in Nepal (e.g. Petley et al., 2007), dominated as it is by the monsoon. Reflecting on the risks posed by landslides, there was a clear recognition of the need for a preparedness plan for both householders and the wider local community. Areas that could be targeted with such a plan were suggested as follows: storage of household groceries in case of being unable to obtain supplies; advance planning with regard to visits, for example, to relatives, and also in relation to other necessary activities prior to the start of the monsoon.

7.3.1 PMEs as an integrated approach for assessing landslide hazards

The use of PMEs here had two purposes: community mapping of landslides as discussed above; and facilitating discussion about landslide hazards and risks. The exercise was guided by five themes (see Section 7.3), which were reflected in the mapping and the accompanying discussion. The PMEs showed that an assessment of risk could be possible not only through compiling an inventory but also by including detailed community knowledge about landslides based on observations and individual experience, for example, their geology and predicted runout areas. The PMEs also tentatively demonstrated the opportunity to validate maps prepared using more scientific methods by assessing which landslides were active, and also which posed either a real or perceived threat.

Furthermore, as often mentioned by the participants in both case study communities, the *local impact of landslides* was the focus, particularly where they had an impact on livelihoods. In addition, these concerns were often related to resources. As Oven and Rigg (2015) found, householders in on-road locations typically take advantage of other roadside locations for livelihood support and other benefits. Because the off-road locations have more limited access to resources for diversifying people's income sources, locals have to travel to roadside locations for everyday activities such as daily wage labour. As a result, concerns were mostly about landslides posing bottlenecks, causing villages and their residents to become isolated due to obstructions. These feelings were reflected in the PMEs, during which participants placed red Lego to indicate the most threatened locations. Identifying such high-risk locations, which were felt to require mitigation, often led to the articulation of expectations of external support, particularly where mitigation was deemed beyond the capacity of the community. In discussing the governance of the problems raised during the PMEs, the participants expressed a wish that rather than paying external contractors, they would prefer local participation in mitigation efforts to be ensured, and they also felt that mitigation measures should be implemented with full financial transparency. Not every participant mentioned the need for proper plans, but most expressed their opinions as 'expectations' that local DRR can only be achieved with strong institutional support (from note M-22-GK).

The PMEs integrated community-held and external knowledge, and one of the benefits of this was being able to assess how any local monitoring could best assist communities to enhance their resilience to future risks. A systematic or formalised approach to local monitoring has the potential to reduce significantly the risk faced by people living on steep slopes or even in areas where there is creep, because it provides information on the location of unstable areas and rates of instability, and helps to identify those locations that might fail in future (Dikshit et al., 2020). The PMEs illustrated that the priority was fast-moving landslides, which tend to fail during the monsoon or without an apparent trigger, whereas the slow-moving landslides received less emphasis. This example was clearly noted in two of the meetings (Chhyadi, PME 1 and 2), which were attended by villagers who lived next to creeping areas. In Chhyadi village, some householders were afraid of the creeping slope that was located in the middle to bottom part of the village, although this area was not identified to be of concern in the first discussion. When the potential impact of landslides was discussed later, some of the participants identified the (perceived) threat to householders who experience disruption on their everyday life due to the constant movement. In such conditions, local monitoring can be proposed to allow the local community to self-assess the risks. Potentially, locally improvised measurement of movement could be the best way of monitoring such slow-moving landslides, because it would enable people to take early action as and when things changed.

At the start of the research, the potential of the PMEs for exchanging knowledge between the community and experts was considered to be one of the best opportunities for increasing awareness of landslide risks. Although the focus here was on householder knowledge, there is also clear potential for scaling up the approach by exchanging knowledge with local authorities. In discussing the value of the maps created during the PMEs and those drawn by experts, the discussion led to the following suggestions as to how the maps could be used: (a) to indicate the most likely places that would be affected in a rainstorm event after a landslide; (b) to help communities learn about different types of landslide and their impacts, with the aim of identifying the most risky places; (c) to aid planning for development, land use and soil conservation; and (d) to help local planning in relation to landslide hazards and risks. I purposefully did not include a geomorphological or geological map in the PMEs, but in retrospect, it could have been beneficial if accompanied with an adequate explanation. However, I was equally aware of the challenges of introducing geological information: participants' unfamiliarity with this type of information (Stewart and Lewis, 2017); and confusing participants with too much information (Lindell and Perry, 2003). One consequence is that the PMEs did not include a discussion about surface conditions versus the role of lithology/soil to investigate the generalised community understanding of 'materials beneath us', and their role in generating landslides.

Through the discussion described in this part of my thesis, the locally prioritised issues in relation to LRM in the UBK could form a focus for future risk governance (Wachinger and Renn, 2010, p. 67) in terms of the following: (a) community-focused plans for risk management; (b) hazard and risk mapping with communities; (c) supporting a strong institutional set-up that defines the roles and responsibilities of local stakeholders; (d) raising awareness via an enhanced mechanism for risk knowledge exchange; and (e) providing guidance on choices available in relation to proposed developments based on the locally developed risk assessment that has considered perceived levels of risk.

7.3.2 Challenges of PMEs and lessons learned

I have documented some challenges I faced in conducting this part of the research that would need to be considered before repeating this exercise. The practical challenges include the following: the *scale of the map* and its resolution; the suitability of satellite images; establishing a proper and effective working protocol for conducting the exercise; and the optimum group size and composition. These are discussed briefly below.

The first noted challenge during the exercise was the image quality, which was often found to limit the visibility of the ground, making it difficult for participants to recognise features (Galli et al., 2008). Although the image quality was good, sunlight resulted in strong shadows and saturation of bright areas, meaning many sections were not clearly depicted. The map would have worked better if the image had been printed at a bigger scale so that it focused on only a limited area of interest, which may have resulted in a clearer view of features. It was also apparent that not all participants have an equal understanding of the geography of the area, particularly where recent changes may have occurred, as similar to the findings of Klonner et al. (2016, 2018). This was particularly the case after the earthquake, and the difference between off-road and on-road communities was seen in both the household survey and the PMEs. The off-road participants had a longer history of living in the same place and, therefore, a better knowledge of their localities. This was reflected in their mapping, which encompassed more of the local area. Many of the householders in on-road locations, although local, had lived there for only a relatively short period of time; therefore, the resulting mapping tended to be aligned along the road network, mirroring the geography of the daily activities and livelihoods. The results may have been different or clearer if it had been possible to conduct a similar exercise before the 2015 GE, when the valley was far more densely populated, particularly along the road, and the residents were from various parts of Nepal and beyond. After the earthquake, most of the people who remained were residents of local origin, so this might have influenced the results, given their familiarity with the landscape.

This familiarity can also be a problem in that participants may overlook or overfocus on particular features, attributing a higher or lower weighting of risk to their own neighbourhood, farmland and areas they travel to during their daily routines. Again, this is a tendency observed elsewhere (see Klonner et al., 2018, p. 15). Mitigating such bias has been important in similar risk assessments at the local level. Another weakness of the PME approach is the lack of high-resolution images, particularly imagery that can show the small-scale landslides typical in the field area. Even 'smaller landslides have the potential to block steep, narrow valleys and therefore needed very high-resolution' (Williams et al., 2018, p. 190). Typically, these are less than 5 m in width, and often hard to see on a map. There was also a clear need for imagery from different dates, according to which the community can confirm the changes based on the information available for different time periods, validated by their own first-hand experience. In the PMEs, the post-earthquake image was shown to the participants to verify their own mapping. Despite the benefits of PMEs, free and easy availability of up-to-date high-resolution images for use in similar exercises by communities is still challenging because of difficulties in accessing the necessary IT resources to obtain such maps in the first place, and then large-format printing; in addition, there is the cost involved.

An effective mapping exercise is only possible when the time participants have available is sufficient to enable their full and active engagement, so that to some extent, true ‘participation’ is achieved (Amsden and Vanwynsberghe, 2005; Rambaldi, 2010; Reichel and Frömming, 2014). I encountered definite challenges in this respect, particularly with regard to people having limited free time, notably during the busy harvest season after the monsoon when this part of my field research had to be conducted. However, I tried to overcome this challenge somewhat by trying to make the PMEs as inclusive and representative as possible to encompass a wide range of views and experiences. All sectors of the community were involved: the grassroots, including less able people; people of different ages, genders and identities; and people regarded as knowledgeable. (Mercer et al., 2008; Wanasolo, 2012).

The time allocated for each PME was about an hour, and arrangements needed to be very flexible to fit around participants’ availability. I observed that the allotted time was not sufficient for a full and detailed discussion, mainly as the participants had so many queries at the end of the session. If the timing of the events could have been more flexible, it would have been possible to capture more details on the participants’ views, but my wishes conflicted with wider demands on their time. In addition, as per the objectives for the session, we intended to minimise the disagreements among participants, and try and ensure that no single participant dominated the discussion, which was common. Although I had fixed objectives for the session, in future, more flexibility would allow the mapping and the discussion to develop more organically, which may result in a greater depth of data and analysis. My experience shows that the facilitator’s role is crucial, not only as the researcher, but also in ensuring full participation, encouraging everyone to put forward their views, giving everyone sufficient time for discussion and helping participants fully realise their ownership of the session in the process (O’Neill, 2004; Chambers, 2006; Acker et al., 2010; Klonner et al., 2016).

Completing the PMEs successfully was a challenge, largely due to the difficulties of coordinating a sufficiently engaged group of participants during what was a busy time in the agricultural calendar. Similarly, the large-scale imagery I was using covered most of the territory of the *gaunpalika*; hence, features of interest were either small or often invisible. Because of the broad level of relief, many areas of interest were shadowed or fully obscured, again making interpretation of the imagery difficult. The PMEs were successful in adding further to the differences between on- and off-road settlements with regard to the landslide risk knowledge originally identified in the household survey. Overall, participants showed a good geographical awareness of the valley and their own position within it, which was encouraging for the future use of mapped information. This awareness was also mirrored in a relatively good understanding of the scientific mapping of landslide hazards and risks, although it was noted that the complexity of these maps perhaps made them difficult for local people to interpret.

7.4 Live demonstration

The challenges discussed in the above sections identify a series of knowledge and information gaps in relation to landslides and means of reducing the risks they pose. For example, participants constantly articulated expectations with regard to external support for addressing landslide issues, so it would be useful to clarify how costly structural mitigation measures are, and how appropriate they would be in reducing landslide risks in this setting (Jaboyedoff et al., 2016). Thus, the landslide demonstrator was created specifically to tackle some of these knowledge gaps, and its development was based on previous successful live demonstrations of other geohazards, for example, the NSET earthquake shake table. Using a single simple platform, the demonstrator, which simulates landslides and the processes through which they occur and evolve, has the potential to enhance significantly people's understandings of changing landslide hazards, their exposure and the associated risk. This type of approach is aligned with the priorities of Nepal's periodic plan, which recognises that disaster risk management has to be part of the development process at the local level through institutional and structural reforms (NPC, 2020, p. 62). In line with this policy, plans for disseminating information on landslide hazards and risks are essential for raising awareness and guiding appropriate risk mitigation at the local level.

7.4.1 Live landslide demonstrator

Against this background, the demonstrator was conceptualised as an awareness-raising tool to educate communities about landslide hazards and risks. It was based on a rotational landslide, the features of which are common to many areas of rural Nepal. The demonstrator was intended to help the community understand the technical and financial feasibility of mitigation but, critically, it was based on a simplified understanding of the mechanisms that lead to the occurrence of landslides that are often not directly witnessed. The demonstrator was also intended as a way of dividing risk into its constituent parts of hazards and exposure, again as a means of exploring alternatives ways of reducing risk. In addition, a component of the demonstrations explored the potential for local monitoring of landslides as a means of raising awareness about areas most at risk and when. This information will be essential for local area planning in relation to the location of basic infrastructure and future settlements. Furthermore, the approach is not just intended for rural communities, but is also expected to be useful for training students in schools, colleges and universities in the practical aspects of landslides. Finally, the approach will be useful in advocacy for decision-makers at all levels.

Research has demonstrated that 3D physical models are influential tools for communicating information on hazards and risks (Upadhyay, 2004; Haynes et al., 2007; Wagner, 2007; Gaillard and Maceda, 2009; Dixit et al., 2013; Sanquini et al., 2016a; Chaturvedi et al., 2017; Hicks et al., 2017). However, there is almost no experience of the use of community-facing physical models for demonstrating landslides and, in particular, of an approach that indicates how landslides change over time (Hungr et al., 2014). According to the knowledge gaps found, it is vital to include this dynamic element. In a context of sharing and debating knowledge about the causes and consequences of landslides with communities, a physical model could be a very effective way of building community awareness and capacity with regard to landslide hazards and risks (Chaturvedi et al., 2018), especially if it aims to demonstrate the fourth (temporal) dimension of landsliding and how hazard translates into risk.

Based on these practical demands, the demonstrator was used to model common rotational landslide characteristics, and a protocol was developed for presenting it to communities (the demonstration). Trials took place in two communities and also in front of an expert audience during a workshop held at NSET in Kathmandu. Within the constraints of the available time, I evaluated the initial influence of the model on community understandings of landslide hazards and risks by collecting feedback from participants. This section of the thesis summarises the main findings, and then discusses the apparent strengths and weaknesses of the demonstrator and demonstration based on my own reflections and the feedback from the communities and expert groups. An attempt was made to identify misconceptions or misinterpretations that have become apparent throughout this research, and then explain and discuss them (Niewöhner et al., 2004). The feedback will be used to inform future improvements to the approach, and its potential role in empowering local communities to initiate landslide risk reduction activities will be assessed.

The key findings from the demonstrations can be summarised as follows: (a) the model was an excellent way of triggering a very engaging discussion about landslides and the problems they pose; (2) the model got people talking about landslide mechanisms and processes and, in particular, inspired consideration of the sub-surface for the first time; (3) the model formed a reference point that people were then able to link with places/features they knew in the landscape; (4) the model was able to show how landslides change over time and, essentially, it demonstrated the evolving dynamics of landslide hazards and risks; and (5) the model was able to show features of landslides and put them into the context of the landslide as a whole, and then the wider landscape, as a means of better anticipating how they might change in the future.

My changing role when doing the research, especially during the later use of the demonstrator, involved a shift towards that of an expert from the independent (student) researcher. Sometimes, this positionality challenged me, in for example establishing the authenticity of the demonstration. The confidence of the local community members, during the demonstration, with me as an expert demonstrator was kept in consideration by being transparent in all discussions, and through explaining my previous experiences and work, with the intention of trying to add confidence in how valid increasing awareness and knowledge around hazards that people experience day to day. I tried to sustain this transparent approach, was open in discussion, and explained how meaningful and beneficial the process of exchanging knowledge and learning from each other could be.

7.4.2 Expert feedback on the landslide demonstrator

Expert feedback has been important at each stage of the model development. Before the demonstrator was trialled in the community, an on-site workshop was held at NSET that included academics, DRR practitioners, sociologists, engineers and geologists. This workshop provided valuable feedback with regard to improvements that needed to be made to the demonstrator: the detail and scale of the model; the processes simulated; and the manner in which it should be presented to the community. It was also important to share the experiences and lessons from the community demonstrations with a wider community, including professionals, community and other experts, geologists and other interested parties. I organised another workshop in Kathmandu after the community demonstrations to share my experiences. The overall goal of this was to present the demonstrator with a focus on the following: (a) sharing the concept to inform its future development; (b) conducting an example live demonstration to see how it was received; and (c) collecting suggestions for the future use of the approach in the context of the middle hills area of Nepal. This second workshop was attended by 31 delegates from diverse backgrounds, including NGOs, donor agencies, professors, DRR experts and geologists.

The overall response from workshop participants confirmed the potential value of the model, the approach and the materials sourced from the community. During the workshop, the initial findings from the household survey and PMEs were also presented as the background for the emphasis of the demonstration. Again, feedback was valuable, not only for its technical input, but also in relation to the content of the presentation, the model's appropriateness for use at the community level and its overall potential for future scaling up. The workshop participants broadly agreed on the potential value of the approach taken, and in particular on the incorporation of ideas in relation to hazards, risk and the changing exposure of communities. One thing I am particularly proud of, and that I am eager to pursue when I return to Nepal, is that since the completion of my PhD research, the approach has been rolled out my colleagues at NSET as part of an EU ECHO HIP-funded programme in about 120 communities in Sindhupalchok District. The rollout is stimulating discussion and providing valuable suggestions for the development of the approach.

Despite numerous studies on the physical characteristics of landslides in Nepal, many focus only on site-specific problems. There have been far fewer in-depth studies considering community experiences of landslides that seek to develop more general strategies for managing hazards and risks. For instance, filling in the gaps in the knowledge about 'what lies beneath us' is especially important in taking any action and ensuring that mitigation measures are not just superficial and, hence, unsustainable, which is commonly the case in Nepal. The demonstrator has been envisaged as an approach that has the potential to combine observations that people make day to day with a deeper level of understanding of the processes of landslides and how they change over time, and also with potential ways in which communities can manage these risks within their own means.

In the same expert workshop, a further iteration of the demonstrator was presented that includes the impact of rainfall on landslides that are more akin to debris flows. This model is still in development at the time of writing and so is not reported in detail here. Technically, this version operates at a similar scale, with a 90 cm-long, 60 cm-wide and 75 cm-high enclosure, held within a steel frame. However, it is enhanced with nozzles overhead that spray artificial rain to represent heavy rainfall. In this model, we tried to trigger landslides and debris flows with rainfall after the ground became saturated. Initially, after the application of rainfall, streamflow developed in channels towards the lower sections of the model. Next, under increased rainwater channelled by roads, the surface runoff overflowed and started to cut a more direct route downslope akin to the start of a debris flow. On steep areas of the model's surface, participants can see how poor storm water drainage deepens channels along the road and creates instabilities associated with the road alignment, gradient and side drains. The model does not intend to show mitigation measures at this stage. As an awareness tool, it remains cost-effective and equally replicable, albeit slightly more complex than the original demonstrator. If mitigation ideas were also incorporated, the financial cost and time to set up the model would inevitably escalate, but it would be valuable to explore how this could be done in the future. Therefore, the purpose of this second model currently remains limited to discussing issues with participants, raising questions and offering suggestions for mitigation. The next level of demonstrator development could perhaps show the benefits of structural and non-structural measures for mitigation, including bioengineering, drainage management, check dams, plantations, land use plans, etc., in two identical models.

7.5 Next steps – further research opportunities

In 2020, 568 people lost their lives due to 3,659 disaster events in Nepal, amounting to a direct loss of NPR 2 billion. Landslide events had a bad impact on the country, and in 2020 a total of 301 people lost their lives in this way, whereas floods killed only 42 people. Within the BKGP, 8 landslide events were recorded during the monsoon period of 4 months, in which a total of 31 houses were destroyed (BIPAD Portal, 2021). Therefore, my study has sought to contribute to a wider body of work that attempts to be useful in understanding and reducing the devastating perennial hazards that people in these communities face.

My research reveals the significant relevance of local knowledge of landslides for hazard assessment in the BKGP at the local level, and based on my findings, I strongly suggest that this knowledge and the community needs articulated in this thesis should in future be included alongside more formal data in decision-making. The comments from the household survey, often based on a good level of knowledge about the landslides alongside which the people live, show that the local householders have increasing confidence in and expectations of locally led mitigation of these hazards if they understand the processes involved. The existing knowledge gaps could be addressed using hazard maps, with local information added via a process such as participatory mapping, as trialled here. In this context and to finalise my thesis, in the following final two sections, based on my own research findings, I put forward ideas for further research that could enhance community understandings of everyday landslide hazards and risks.

7.5.1 On local understandings – using the household survey and PMEs

Following the above discussion, the research ideas described below may further help to enhance community understandings of landslides, and how the risks people face can be reduced:

1. The household survey method applied in this research is a relatively quick approach for assessing respondents' understandings of pertinent local issues, including landslide risk. This can form a basis for assessing perceived hazards and risks, including those from other sources such as floods, climate change or GLOFs. In the context of landslide hazards and the rapid changes ongoing in Nepali, a longitudinal survey, revisiting the same respondents time and time again would be highly valuable as a barometer for what risks people are facing and how these are changing within the wider context, if it were possible to sustain such a survey.
2. During post-earthquake reconstruction, the local community expected help from the government in relation to a detailed assessment of hazards and risks such as landslides. Beyond this extraordinary appraisal, such assessments are not commonly available or conducted in rural communities such as those that experienced the severe impact of the 2015 GE or in areas where landslides have further intensified after the impact of more recent monsoons. Both of these scenarios include the communities of the UBK. In such a context, and where actual government capacity remains very limited, a self-assessment guideline for ground evaluation could be extremely useful for community safety so that householders could self-assess for landslide risk at a first level of screening. 'Simple rules' (e.g. Milledge et al., 2019) or checklists could be a very useful tool for involving local knowledge to identify potential at-risk locations. Such efforts would contribute to the gradual establishment of a local safety culture.

3. In the context of high-magnitude landslide events, such as the Nagpuje and Lidhi incidents in Sindhupalchok District in 2020, a detailed community risk perception survey could be of high importance for understanding the background to those events and especially for investigating whether slope instability problems were an existing concern, and whether each event could have been predicted. Such information is needed to assist in identifying appropriate mitigation alternatives. The number of events that could have been predicted for which risks or indicators of future instability were ignored remains unclear. Such an approach is essential to enable risk reduction efforts to focus appropriately on those landslides that can feasibly be mitigated, as it is simply not the case that one size fits all.
4. This study briefly considered how the 2015 GE triggered landslides that affected people's livelihoods. Further studies of the role of the livelihood dimension of landslides, and how this is integrated with local understandings of hazard and risk, would be extremely valuable for guiding disaster risk governance by the local government, and for informing larger-scale investment by the federal government and donor agencies. As shown here, the detailed household survey has the potential to provide further insight in this respect. One significant factor that emerged from the household survey was that there is diversity in local communities in terms of caste, ethnicity and cultural practices, and that people's different views according to these characteristics influenced the way they dealt with the earthquake and the subsequent landsliding. This variability and how it intersects with landslide hazards and risks is an important issue that deserves further exploration.

7.5.2 The landslide demonstrator

Below, I provide a brief discussion on potential future avenues along which the research on the landslide demonstrator could be developed:

1. The next iteration of the demonstrator, as described above, would incorporate more familiar landslide triggers, notably rainfall, which is essential in the Nepali context. One factor that is apparent from my work is the clear need to consolidate the messages from the model to 'leave something behind' with the community in terms of knowledge. The development of a set of standard guidelines, a more refined protocol for the model's presentation and the key messages that should be at the centre of the dissemination of information in the future, all presented in a locally accessible (in terms of language, literacy and sensitivity to gender) and transferrable manner are critical next steps in making this a tool that is more widely useful, and usable by others.
2. Building on the success of combining the process of participatory mapping and the demonstration, a next logical step would be to build the demonstrator in a more participatory manner by involving the communities themselves. Local students and teachers would be a great

asset in further refining the technology and the experience. This would draw on the widely researched benefits of participatory approaches and help to develop the demonstrator to a point at which it is not just a tool for knowledge transfer.

3. A critical element of the model at present is the challenge of linking each demonstration to the community and setting in which it is being demonstrated. Therefore, it would be beneficial to try and replicate local topography in each model to help participants better relate what is shown in the demonstration to their own environment. To make some progress towards this, the EU ECHO HIP-funded project in which the demonstrator is being rolled out also includes the use of a large-format 3D printer to build models based on local topography.
4. A final element of further improvement of the model relates to scale. It is recognised that larger models can include more recognisable features and processes. The original proposal for the demonstrator was to build it in the back of a tipper truck, but this was not feasible within the available budget. However, it would have the advantage of transportability, replicability and 'spectacle', and is something I am keen to pursue in the future in my work on this topic at NSET.

Appendices

Appendix 1. Guidelines for participatory mapping exercise

The activity schedule for focus groups and participatory mapping in the community.

Lead facilitator: Gopi K Basyal

Associated facilitator: Rajat Bastola

Estimated time for one participatory mapping exercise – 1hr 25 min.

Introduction (10–15 min.)

- Brief introduction of the study/research – start with the background (estimated time 2 min.).
- Want to **share key findings briefly** from the previous survey (carried out October–December2018), along with the researcher's observations about these (estimated time 2 min.).

The focus group will discuss the following (this will be explained briefly at the start for guiding discussion):

1. How landslides are changing over time in the villages,
2. How landslides are varying spatially,
3. How the exposure to landslides has changed over time,
4. How landslide risk is being managed at the local level,
5. And what are the major concerns of local people in moving forward in terms of landslide risk reduction (for the future) – how this research and information from local communities will feed into local disaster risk reduction plans such as community-based disaster risk reduction tools, Durable Solutions, local governance for hazard risk assessment, etc.,
6. Any questions participants may have (at the end of discussion),
7. Briefly introduce the five steps of the exercise.

Consent *and permission:*

After introduction, obtain permission and get consent verbally if they are willing to participate in the exercise. Participants are free to withdraw from the discussions, anonymity, etc.).

(1hr – 1hr 10min.)

Step 1: Introductory

i. Satellite image: printed images (A0 size) of pre-earthquake (2015 Gorkha earthquake) position will be shown to open the discussion.
ii. Locate features of common interest at first, followed by houses, schools, community forest, *gumba*, etc.

Step 2: Mapping landslides

iii. Mapping landslide activity will be conducted after general familiarisation (as mentioned in 1 and 2 above) with mapping features.
iv. When mapping landslides, participants will first locate them (indicate on map) and then categorise them according to their characteristics as per participants' understanding. Categories will include big/small, wet/dry, fast/slow, fatal/property loss only, etc.

Step 3: Exposure mapping

v. Exposure mapping in terms of daily, half-yearly/yearly. In this activity, daily visits, for example, to school (children), farmland (farmers), daily work (day labour), will be mapped. Similarly, seasonal exposure including the half-yearly and yearly exposure of villagers will also be discussed and mapped.

Step 4: Risk reduction/mitigation measures

vi. This step will include a question on general practices of landslide risk reduction/mitigation measures in the village, both traditional and current.
vii. What do you do now that you didn't do before the earthquake?

Step 5: Comparison with maps prepared previously, conclusion and wrap-up.

viii. At the end, participants can compare the maps created during PMEs with the maps created by Durham University/NSET showing the situation before and after the 2015 Gorkha earthquake.
ix. Maps created by Durham University/NSET will be introduced to compare the information therein and participants' opinions with their attitudes towards the base maps.
x. Any questions from participants with regard to the maps. Do they agree with them? Will they be of benefit to the village or local hazard risk assessment?

Conclusion and wrap-up with thanks.

Appendix 2. Guidelines for participatory mapping exercise

Activity: Conduct participatory mapping exercises to map local landslide hazard risk as perceived by the community participants.

Aim of the activity: Map community understandings and analyse landslide hazard and risk as perceived by the community members (villagers) in two locations of Sindhupalhok District, Nepal.

Method: The group participatory mapping exercise will be undertaken by community members and facilitated by the researcher. The five steps are based on mainly Gillard et al., 2013 and Dunn and Williams, 2003: (a) base map used for exercise – true-colour, A0-size Google Earth images; (b) participants will place understandings of the local landscape on top of the base map, thereby compiling an inventory of landslides of different sizes, speeds, etc.; (c) information on exposure to the landslide hazard will be added, thereby creating risk, according to the community view; (d) finally, a community consensus map will be prepared. Therefore, several layers of information were generated and integrated to produce an output map showing hazard and risk. The details are listed in the table below.

Step/activity	Aim of activity	Activities in participatory mapping exercise	Output/outcome and its use
Overall: Compile information from participatory mapping exercises undertaken in communities with the aim of understanding landslide hazard and risk.	▪ Gain insight into the hazard and exposure experienced by the community as understood by community members. ▪ Look at the changing exposure of vulnerable households, communities, the population in the villages as per the community's perspective, knowledge and understandings.	▪ Participants will locate (indicate) the local landscape in the first phase of the exercise. ▪ Landslide hazard locations (primarily), also exposed houses, households, communities, farmlands, settlements, schools and infrastructures on the map. ▪ Different groups of people from the community will generate different maps. The output information will be based on their knowledge and understanding of landslides. ▪ Two communities have been selected for the exercise, one on-road (Larcha), the other off-road (Chhyadi).	▪ As a final output, produce a consensus map as per community members' perceived level of risk. ▪ Two different locations will be compared, that is, how people evaluate risk as per each location. ▪ A comparison over time according to local priorities. ▪ Result maps show different landslide risks based on local understandings of landslide (hazard) location, type, the threat posed, changing exposure and mitigation measures taken in terms of landslide risk management.
Landslide inventory map at community/ village level.	▪ Understand how participants (community members) identify and locate landslides around the village. ▪ Assess how accurately	▪ First stage of mapping will be familiarisation with features such as rivers, roads/trails, major landmarks, school buildings, etc. ▪ Landslide inventory using the base map. In this process, participants start indicating the location of landslides around	▪ A map on which features are identified, representing participants' understanding of their local landscape ▪ Landslide inventory map: mapping landslides according to participants' knowledge of landslide locations, their sources and their areas of impact.

Step/activity	Aim of activity	Activities in participatory mapping exercise	Output/outcome and its use
	participants can identify the sources of landslides.	their village/community as per their knowledge. ▪ The method could be a sketch, the marking of a point or delineation of the area.	▪ An assessment of in how much detail and how accurately participants can identify landslide locations on the printed Google Earth image.
Types of landslide.	▪ Understand how community members differentiate between types of landslide and classify them.	▪ Help participants to categorise landslides according to their understanding: most recurring (frequent), size (big vs small), depth (deep or shallow), old/new, dry/wet, slow/fast, source materials, etc. ▪ Use of coloured paper and pens to plot features on the map. ▪ Lego bricks are used for categorisation according to their colour and size.	▪ Simple landslide classification maps showing community perception of how landslides are classified locally. These community categories will be useful for priority setting and selection of mitigation measures, including early warning systems. ▪ Moreover, capacity in relation to selection of mitigation options.
Landslide trigger factors.	▪ How participants recognise triggeractors.	▪ List and identify the trigger factors and where they occur. ▪ Plot (identify and mark) the landslides triggered due to rainfall, road construction, construction of other infrastructure, earthquakes and others. ▪ Ensure detail is captured on participants' knowledge about what conditions, factors and events can trigger landslides, for example, earthquakes, road construction.	▪ The output map will demonstrate community knowledge about the trigger factors. ▪ Useful for short- and long-term preparedness, mitigation measures and long-term development planning at the local level.
Effect of landslides.	▪ How landslides have an impact locally. This includes road blockages, disruption to transport, loss of farmland, etc. ▪ Which families are directly affected and how, for example, lives and livelihoods?	▪ List or locate on the map the loss records according to community memory. ▪ Locate where the loss (human lives, houses, schools, water supply, local roads, other), occurred in the past. ▪ Locate the areas of potential risk for future reference, that is, risky areas, households, roads, bridges, school buildings, etc. ▪ List and locate mitigation measures taken (if any) and their type.	▪ Shows which are the most affected areas and why. Information on which areas that are most hazardous have experienced loss previously and who lives there. ▪ Knowledge about why people live in such marginal areas and an assessment as to whether a household's proximity to the landslide location is linked to its economic status. ▪ Identification of potential threats to their house, property and community in the future.

Step/activity	Aim of activity	Activities in participatory mapping exercise	Output/outcome and its use
Daily exposure to landslides.	▪ Recognise the daily exposure to landslide or other hazards.	▪ Locate and map/mark daily commuting areas, places where participants (villagers) travel to: farmland (*khet, baari, ghas-daaura, gaai-bastu charaune*), school (children), job location, place of daily wage labour, etc.	▪ The output shows the everyday exposure villagers live with. ▪ Indication of where people travel to daily to carry out necessary tasks.
Monthly, half-yearly, annual exposure to landslides.	▪ How do participants recognise weekly, monthly, half-yearly or annual expose to landslide hazard risk?	▪ Locate and map/mark the visits made either to satisfy essential needs or to visit relatives: every day, weekly, monthly, half-yearly, annually. ▪ Frequency of travel? Locate those areas outside the village such as village office, *gaunpalika* office, place to meet relatives, market, Kathmandu or any other place. ▪ Seasonal migration? In any season? Or due to job or availability of work?	▪ Gives a better understanding of monthly exposure. ▪ Shows the community's movements during different times of the year. ▪ Gives an indication of hazards and risks they perceive during different times of the year, especially if community or householders decide to move their place of residence due to the landslides.
What mitigation measures are taken (the practice of landslide risk mitigation)?	▪ Find out what local people understand about mitigation measures.	▪ Try to compile an inventory (list/mark on map) according to the type of measures taken. ▪ Establish the funding available (if any): individual construction; local funding from *gaunpalika*; funding from the highways department; funding from a NGO; joint funding; private contractors; hydroelectric power project? ▪ What type of mitigation measures: structural; non-structural; bioengineering? How do they perceive what is suitable or appropriate? Do they think mitigation can be done better?	▪ The output map gives the inventory of mitigation measures taken for landslide hazard in the community. This will provide a clearer picture of types of actions taken locally and local practices. ▪ Information on where the funding comes from. Do the villagers seek it, or is it offered by the local government? Information on what techniques are in place for mitigation: local practices; structural; non-structural; bioengineering. ▪ An assessment of how effective the measures are.
Time series landslide maps	▪ Understand the community's memory of previous landslides. How much do local people know about the landslides around the village?	▪ This will be inferred from the inventory map. ▪ Locate landslides as per the time/date/year of initiation as remembered by the participants. If possible, identify the approximate date the landslide first occurred. ▪ The memory might have been passed from generation to generation.	▪ An understanding of the community memory of previous landslides. ▪ This will apply knowledge transfer in relation to risk.

Step/activity	Aim of activity	Activities in participatory mapping exercise	Output/outcome and its use
Before and after the 2015 Gorkha earthquake.	▪ How community members differentiate between the earthquake-triggered landslides and those already in existence.	▪ Categorise landslides occurring before and after the 2015 Gorkha earthquake. ▪ Which have become more dangerous after the earthquake?	▪ Community understandings before and after high-magnitude hazard events, using the 2015 Gorkha earthquake-triggered landslides as an example.
Hazard and risk map. Map compiled by the community.	▪ Understand community landslide risk as perceived by the community members.	▪ Compile, overlay, visually analyse all information and produce a risk map.	▪ Landslide hazard and risk analysis as per community understandings. ▪ Map for comparison purposes.

Appendix 3. Letter requesting consent from the *gaunpalika* to conduct the research

मिती: २०७५ / ३ /१८

श्रीमान अध्यक्षज्यू
भोटेकोशी गाउँपालिका कार्यालय
फूल्पिङ्कट्टी, सिन्धुपाल्चोक ।

विषय: **अनुसन्धान कार्यका लागि आवश्यक समन्वय तथा सहयोगको व्यवस्था गरिदिनु हुन ।**

महोदय,

उपरोक्त सम्बन्धमा भूकम्प प्रविधि राष्ट्रिय समाज -नेपाल (National Society for Earthquake Technology (NSET – Nepal)) र संयुक्त अधिराज्यको डरहम विश्वविद्यालय (Durham University) विचको सहकार्यमा विगत लामो समय देखि ' नेपालमा पहिरो जोखिम न्यूनीकरण' सम्वन्धी शोधकार्य भईरहेको छ । यस अन्तरगत भोटेकोशी गाऊँपालिका क्षेत्र भित्र पनि वि. सं. २०७२ को भूकम्प पश्चातको पहिरो तथा त्यस पछिका वर्षहरुमा पहिरो को जोखिम तथा पहिरोमा आएको परिवर्तन वारे तथा नक्सांकन एवं अनुसन्धान कार्य भईरहेको छ । यसै सन्दर्भमा यस भूकम्प प्रविधी राष्ट्रिय समाज – नेपाल (एनसेट नेपाल) मा कार्यरत गोपीकृष्ण वस्यालले एनसेट र डरहम विश्वबिद्यालयको भूगोल विभाग, प्रकोप, जोखिम तथा उत्थानशीलता संस्थान (Institute of Hazard, Risk and Resilience, Department of Geography, Durham University) अन्तरगत उल्लिखित शीर्षकमा यस गाउँपालिका क्षेत्रभित्र शोधकार्य गरिरहनु भएको छ । सो अध्ययनको क्रममा यस गाउँपालिका क्षेत्रभित्र केही वडाहरुमा विभिन्न चरणमा केही घरपरिवार सर्वेक्षण, पहिरो अवलोकन, नक्सांकन तथा पहिरो जोखिम सम्वन्धि समुदायहरुसँग अन्तरक्रिया गर्ने कार्यहरु पनि रहेको छ । यस शोधकार्यका लागी आवश्यक अनुमति तथा अन्य समन्वयात्मक सहयोगको व्यवस्था मिलाई दिनुहुन हार्दिक अनुरोध गर्दछु ।

यस विषयमा केही थप जानकारी आवश्यक भएमा यस कार्यालयमा सम्पर्क गर्नुहुन अनुरोध गर्दछु ।

धन्यवाद सहित ।

भवदीय,

....

सूर्यनारायण श्रेष्ठ,
कार्यकारी निर्देशक

To
The Chairperson (Mayor)
Bhote Koshi Gaunpalika
Phulpingkatti, Sindhupalchok

Re: Doctoral Research on landslide risk reduction in Sindhupalchok, Mr Gopi K Basyal.

Dear Sir,

For your kind information, Mr. Gopi K Basyal, is currently undertaking his research for his PhD on 'Landslide risk reduction in Nepal.' Mr. Basyal has chosen Bhote Koshi Gaunpalika for his case study area because of his knowledge of the area, our previous work here and the ongoing problems with landsliding in this valley. During his research Mr Basyal will be conducting household surveys on landslide risk perception to gauge people's understanding of landslides, talking to both individual households and community members. He will also be aiming to conduct focus group discussions, involving representatives from the Gaunpalika as well as members of communities.

We hope that the outcomes of his work will increase the understanding of landslide risk, and ways in which we may best manage this risk in the aftermath of the 2015 earthquake. Mr Basyal will, of course, return to the valley at the end of his research to feed back the findings, and to try and make these as useful as possible for the Guanpalika. In addition, we have held discussions with the NRA, the DWIDM and Triubhuvan University, about how best to use the results of this research to improve how we manage landslide risk in Nepal.

In this regard, I would like to request you to provide him with the necessary support for conducing his research smoothly. This research not only fulfils his academic requirements, but is also intended to give an in-depth understanding of landslide risk faced by communities and we hope that this will be fed into the municipality's planning for risk mitigation activities in the future.

I can assure you that the data collected and generated within this research will not be shared, and will be used only for research purposes.

Should you have any queries or questions in this regard, please contact me: Prof. Dr Nick Rosser, IHRR, Department of Geography, Durham University at n.j.rosser@durham.ac.uk.

Yours Sincerely,

Prof. Dr Nick Rosser
Institute of Hazard, Risk and Resilience
Department of Geography
Durham University

Appendix 4. Participant information sheet to explain the purpose of the research

Information sheet

Date: …………………………..

Title of study: *Local perceptions and response to changing landslide risk following the 2015 Gorkha Earthquake: Implications for effective risk reduction*

Gopi K. Basyal │Doctoral Researcher, Institute of Hazard, Risk and Resilience (IHRR), Department of Geography, Durham University, UK │ gopi.k.basyal@durham.ac.uk

Academic supervisors

Prof. Nick Rosser | Dr Judith Covey | Dr Katie Oven

Institutional affiliation

This study has been carried out under the Durham University Actions on Natural Disasters (AND) initiative.

Approval

This research has been approved by the Department of Geography Ethics Committee, Durham University, UK.

Aim of the research

The research aims to understand how people perceive landslide hazards and risks and how landslide risk can be better understood and managed with communities.

Purpose

Specifically, this research has four main research questions as follows:

1. How do householders perceive and respond to landslides following the 2015 Gorkha earthquake?
2. How has the understanding of landslide hazards and risks changed over time?
3. What knowledge and capacity do communities have with regard to the management of landslide hazards and risks?
4. How and to what extent do different forms of risk communication support communities to broaden their understanding of landslide hazards and risks with the aim of increasing resilience to landslides?

The study area of the research is the Bhote Koshi Gaunpalika in Sindhupalchok District. The detailed study includes Chaku, Larcha, Marming and Listi villages and their surrounding communities.

Potential benefits

This research will help develop our understanding of how communities understand landslide risk and its underlying causes, with the intenion of increasing the resilience of populations at risk. The findings of this study will be shared among a range of stakeholders involved in landslide risk mitigation and disaster risk reduction activities at the local level, including local authorities and communities, and has high upscaling potential throughout the country.

Kind regards

Gopi K. Basyal | Doctoral Researcher, Institute of Hazard, Risk and Resilience (IHRR), Department of Geography, Durham University, UK

Email: gopi.k.basyal@durham.ac.uk Contact: (+977) 9841-33 56 56

Appendix 5. Participant consent form

Consent Form

Local perceptions of landslide risk and response to changing landslide risk following the 2015 Gorkha earthquake: Implications for more effective risk reduction

Consent form for in-depth interviews and participatory mapping exercises and associated discussions

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Thank you for kindly agreeing to be interviewed/ participate in participatory mapping exercises in the study of 'Local perceptions of landslide risk and response to changing landslide risk following the 2015 Gorkha earthquake: Implications for more effective risk reduction.'

This interview/discussion or the process will be recorded and used for reference by the researcher only. The recording will be destroyed after use. Notes will also be taken throughout. The information provided during the interview will be used by the researcher (Gopi K. Basyal) in his PhD thesis and subsequent publications. All the information with regard to personal identification will be anonymised.

Should you have any questions about the research, please contact me directly.

The aim and purpose of the research in detail are provided in the information sheet along with this consent form.

With your agreement, I would like to use the information that you share with me today in academic and wider publications, and presentations.

Please complete the following:

I agree that material gathered in the interview today can be used without any mention of my name or the institution that I represent. I agree with you mentioning my broad affiliation, e.g. 'local government representative.'

Name of interviewee: ……………………………	Name of researcher: Gopi K. Basyal
Signature:	Signature:
Date:	Date:

Appendix 6. Household survey questionnaire

[Logo Durham University]   ID: …………………….. Date: ……………………..
Location of Survey: …………………….. Surveyor: ………………..

Local perceptions and response to changing landslide risk following the 2015 Gorkha earthquake: Implications for effective risk reduction

Household survey questionnaire

Bhotekoshi Gaunpalika, Sindhupalchok District

Thank you for kindly agreeing to participate in this household survey. This study aims to understand 'Local perceptions of landslide risk and response to changing landslide risk following the 2015 Gorkha earthquake: Implications for more effective risk reduction.' The researcher (Gopi K. Basyal) will use the information provided during the survey in his PhD thesis and subsequent publications. This research will help improve the community's understanding of landslide risk and resilience, and we value your opinion. All the information with regard to personal identification will be anonymised and kept strictly confidential, and used for research purposes only. Should you have any questions about this survey, please don't hesitate to ask me. You can leave the survey if you do not wish to answer my questions.

Your efforts in completing this questionnaire are much appreciated. This questionnaire will take about 45 minutes to complete.

Verbal Consent taken (please tick in the box)

SECTION A: Household profile

(a) Are you the household head? [ ] Yes, [ ] No (if not, who?) …………

(b) Who makes major decisions to your household? [ ] Myself [ ] OR specify …………………

(c) Age ……………………. Gender [ ] Male [ ] Female [ ] Others

(d) Marital status
[ ] Married [ ] Unmarried, [ ] Separated,
[ ] Divorced [ ] Widowed [ ] Others (specify)

(e) Ethnicity
[ ] Brahman [ ] Chhetri [ ] Magar/Gurung
[ ] Sherpa/Tamang [ ] Dalits [ ] Others (specify)

(f) Education level
[ ] Non-literate [ ] Simple literate [ ] Primary level
[ ] Secondary level [ ] Higher secondary level [ ] University level
[ ] Others (specify)

(g) Occupation
[ ] Agriculture [ ] Formal employment [ ] Casual labour
[ ] Own business [ ] Unemployed [ ] Student
[ ] Others (specify)

(h) How many years have your family been living in this village? ………………….years **OR** ………………generations

(i) What are the reasons for living in this village?

[ ] Ancestral (generations) [ ] Own properties
[ ] Easy access to education/schools [ ] Access to (run own) business
[ ] Inexpensive living [ ] Access to work/employment places
[ ] Safety [ ] (because of) Displaced
[ ] Good neighbourhood/community [ ] Others (specify) ………………………..

(j) If displaced (from where? Mention previous address) –
Dist. ………… gaunpalika ………… ward …..

(k) When did you move here?………………………………..

(l) What is your family's main source of income?

[ ] Formal employment (in-country) [ ] Formal employment (out-country)
[ ] Casual employment (Remitt. Out-country) [ ] Casual (short-term) labour (in-country)
[ ] Agricultural/farming [ ] Animal husbandry
[ ] Social welfare/pension [ ] Business (family business)
[ ] Shops (cloth shops, tea shops, etc.) [ ] Others (specify)

(m) What is your family's **other/secondary** source of income?
Specify please (as above category mentioned in (l)) ……………………………………………………………….

(n) Is your present house owned by a member(s) of the family?
[ ] Owned [ ] Rented [ ] Living with other families [ ] Other …………

<u>SECTION B: Questions about current problems in the village and in particular landslides that have happened</u>

1. What are the **main problems** that you face in this village? (list as appropriate)

   …………………………………. …………………………………. ………………………………….
   …………………………………. …………………………………. ………………………………….

2. What are the **main hazards and risks** that you face in this village?

   …………………………………. …………………………………. ………………………………….
   …………………………………. …………………………………. ………………………………….

3. Have you experienced **any landslides** in the village?

   [ ] Yes [ ] No [ ] Don't know [ ] Others …………

4. If yes, what kind/type of landslides have you experienced?
   [ ] Falling rock [ ] (land) Flows [ ] Creeping (very slow movement of land)
   [ ] Land subsidence
   [ ] Others (as explained by respondent – more than one type is possible):……………………………….

5. Can you describe **these landslides** and their **impacts** on your daily life or the village? (open question, list as defined by the respondent, for example, rock fall, (soil)flow, creep (very slow movement of the local area, landslide with sound etc.)
   ………………………………… ………………………………… …………………………………
   ………………………………… ………………………………… …………………………………

6. **Where** do **landslides occur** in your village? (which are those places in and around the village? Such as above the village, below, in fields, in channels, or in other places (specify)).
   ………………………………… ………………………………… …………………………………
   ………………………………… ………………………………… …………………………………

   a. Where are the **source** of those landslides?
      [ ] Top of the hill [ ] Middle (places) of the hill [ ] Riverside, river cutting
      [ ] Roadside [ ] Agricultural land [ ] Steep slopes
      [ ] Others (specify) …………………

   b. Why do (what are the main causes of) landslides happen in these places? (multiple answers possible)
      [ ] Old landslides [ ] Unstable slopes – landscape
      [ ] Road construction [ ] Soil and/or geographical conditions
      [ ] Deforestation/cutting of jungle [ ] Uncontrolled rainwater
      [ ] Development activities [ ] Others (specify as reported) ……………………..)

7. What are the main causes or trigger factors of landslides in the village?
   [ ] Heavy rainfall [ ] Deforestation [ ] Roads (highways)
   [ ] Rural roads [ ] Earthquakes [ ] Others (specify)…………………)

8. What time of year do these landslides occur?
   Month (of year) ……………… Week of the month (if) ……….

9. In what kinds of conditions do these landslides occur?
   [ ] After 24 hours of heavy (continuous) rainfall [ ] After 2 days of heavy rainfall
   [ ] After a week of heavy rainfall [ ] At the end of monsoon
   [ ] After monsoon (season) [ ] After rural road construction
   [ ] Others (specify) ……………………………..

10. Is the landslide risk in your village **smaller or greater** than the risk in neighbouring villages in the Upper Bhote Koshi Valley?
    [ ] (relatively) Smaller than other villages [ ] Same as other villages
    [ ] Greater than other villages [ ] Much greater than other (which?) villages
    [ ] Others (specify) ………………………………………..

11. In your opinion, which are the most problematic places (areas) for landslides within –

   a. Guanpalika? (please mention the places) ……………………………………………………………………………

   b. Upper Bhote Koshi Valley? (please mention the places) ……………………………………………………………………………

   c. Nepal? (please mention the places) ……………………………………………………………………

12. Why are these areas more prone to landslides?
   …………………………………… …………………………………… ……………………………………
   …………………………………… …………………………………… ……………………………………

13. Do you think that landslide risk has increased since the 2015 earthquake in the following locations?

   a. Your village [ ] Yes [ ] No [ ] Don't know [ ] No resp.

   b. Guanpalika [ ] Yes [ ] No [ ] Don't know [ ] No resp.

   c. UBK [ ] Yes [ ] No [ ] Don't know [ ] No resp.

14. Were the landslides that occurred during this year's monsoon more severe than those during monsoons before the 2015 earthquake?

   a. List where and in what conditions they occurred? (specify) ……………………………………
   …………………………………… …………………………………… ……………………………………
   …………………………………… ……………………………………

   b. **Where landslide** risk **decreased** or where **increased**, please explain if you know?
   ……………………………………... …………………………………… ……………………………………
   …………………………………… ……………………………………

SECTION C: Questions about possible future landslides in the village

15. Could landslides occur in the village in the (long) future?
   [ ] Guaranteed 100% [ ] Very likely [ ] Probably
   [ ] Maybe [ ] Unlikely [ ] Don't know

16. In the next 12 months, how likely is a landslide to occur?
   [ ] Guaranteed 100% [ ] Very likely [ ] Probably
   [ ] Maybe [ ] Unlikely [ ] Don't know

   a. What kind of landslides do you think will occur?
   [ ] Rock falls [ ] Flows (soil, mud) [ ] Very slow – creeping
   [ ] Subsidence of hillside [ ] Debris flow [ ] Toppling
   [ ] Others (as explained by respondent)…………………………………..

b. How big or large are the landslides likely to be?

[ ] Size of a (motor) car [ ] Size of a house [ ] Size of quarter of a village
[ ] Size of half a village [ ] Size of a field [ ] Others (as explained by respondent)

c. What are the impacts likely to be?

[ ] Fatalities (might be death) [ ] Injuries
[ ] Loss of land [ ] Loss of house
[ ] Loss of crops (land) [ ] Disruption to roads
[ ] Disruption to water supply [ ] Disruption to electricity
[ ] Disruption to other utilities [ ] Others (specify)

17. In the next 5 years, how likely is a landslide to occur in your village?

[ ] Guaranteed 100% [ ] Very likely [ ] Probably
[ ] Maybe [ ] Unlikely [ ] Don't know

a. What kind of landslides do you think will occur?

[ ] Rock falls [ ] Flows (soil, mud) [ ] Very slow – creeping
[ ] Subsidence of hillside [ ] Debris flow [ ] Toppling
[ ] Others …………………………………..

b. How big are the landslides likely to be?

[ ] Size of a (motor) car [ ] Size of a house [ ] Size of a quarter of a village
[ ] Size of half a village [ ] Size of a field [ ] Others (as explained by respondent)

c. What are the impacts likely to be?

[ ] Fatalities (might be death) [ ] Injuries
[ ] Loss of land [ ] Loss of house
[ ] Loss of crops (land) [ ] Disruption to roads
[ ] Disruption to water supply [ ] Disruption to electricity
[ ] Disruption to other utilities [ ] Others (specify)

18. Do you think future landslides might impact on your own household?

[ ] Yes [ ] No [ ] Don't know [ ] No response

a. If yes, how?

[ ] Fatalities (might be death) [ ] Injuries
[ ] Loss of land [ ] Loss of house
[ ] Loss of crops (land) [ ] Disruption to roads
[ ] Disruption to water supply [ ] Disruption to electricity
[ ] Disruption to other utilities [ ] Others (specify)

SECTION D: Landslide risk reduction – house

19. Have you taken any measures to protect your house and land from landslides?

[ ] Yes [ ] No

a. If yes, what measures have you taken? (Checklist needed)

[ ] Gullying, channelling of rainwater [ ] Retaining walls [ ] Planting trees/bioeng.
[ ] Gabions [ ] *Puja-aaja* [ ] Others (specify) ....

b. If no, why not? ....

20. Have you received any **technical assistance** to manage landslides?

[ ] Yes [ ] No [ ] Don't know [ ] No response

a. If yes, who provided this technical assistance?

[ ] Gaunpalika [ ] NRA [ ] NGO/INGOs
[ ] Other government agency (ies) [ ] Private consultancy [ ] Joint (gaunpalika–community)
[ ] Community social organisations [ ] Other (specify)..

21. What do you think would be the **best** way to manage the risk of landslides in your household?

[ ] Gabions [ ] Masonry walls
[ ] Bioengineering [ ] Engineering (designed walls)
[ ] Drainage, channelling rainwater [ ] Early warning system
[ ] Hazard information [ ] Relocation of (hazardous) settlements
[ ] Land use planning [ ] Indigenous/traditional methods
[ ] Others (specify) ....

22. What do you think would be the **most feasible** way to manage the risk of landslides in your household?

[ ] Gabions [ ] Masonry walls
[ ] Bioengineering [ ] Engineering (designed walls)
[ ] Drainage, channelling rainwater [ ] Early warning system
[ ] Hazard information [ ] Relocation of (hazardous) settlements
[ ] Land use planning [ ] Indigenous/traditional methods
[ ] Others (specify) ....

23. Are you able to spend money to protect your house and farmland from being damaged by a landslide?

[ ] Yes [ ] No
[ ] Don't know (how much it cost) [ ] No response

a. If yes, how much could you spend? (e.g. percentage of household income, fixed amount or equivalent to such as one chicken, one goat, one *muri dhan*, fixed monetary amount)

[ ] One week's salary [ ] One month's salary

[ ] Fixed money (Nepali rupees) [ ] Others (equivalent to goods, specify) …………………..

24. Which of the following information would it be useful to have about landslides for your household?

[ ] Causes of landslides [ ] Size of landslides
[ ] Timing and condition of landslides [ ] Warning signs of landslides
[ ] Types of landslide [ ] Behaviour of landslides
[ ] Others ………………..

25. Have you attended any hazard or disaster risk management training / programmes?

[ ] Yes [ ] No

26. Has landslide risk become more serious for your household since the 2015 earthquake?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

a. If yes, how? ………..

SECTION E: Landslide risk reduction – village

27. How have landslides traditionally been managed in the village? Could you explain if you know something?

………
………

a. Are these approaches still used today?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

b. If yes, can you give some examples? ……………………………………………………………………
………

28. Who is responsible for landslide risk management in your village?

[ ] Individuals [ ] Guanpalika (local authority)
[ ] Community groups [ ] Government agency
[ ] Joint collaboration (Govt.–community) [ ] CDMC (local disaster management committees)
[ ] Private company, businesses [ ] No one [ ] Other (specify)

a. Do you contribute to this?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

b. If yes, please give details (open question) ……………………………………………………………………
………

29. Have any formal landslide management (action) plans been developed that apply to your village?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

a. If yes, please give details (open question/answer)

……
……

30. Have **any measures been taken** to protect your village from landslides?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

a. If yes, what measures have been taken?

…………………………………………………………………… ……………………………………………………………

b. If no, why not?

…………………………………………………………………… ……………………………………………………………

31. Has the village received any **technical assistance** to manage the landslide risk?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

a. If yes, who provided this?

[ ] Individuals [ ] Guanpalika (local authority)
[ ] Community groups [ ] Government agency
[ ] Joint collaboration (Govt.–community) [ ] CDMC (local DMC)
[ ] Private company, businesses [ ] No one
[ ] Other (specify)………………………………………..

32. What do you think would be the **best** way to manage the risk of landslides in your village?

[ ] Gabions [ ] Masonry walls
[ ] Bioengineering [ ] Engineering (designed walls)
[ ] Drainage, channelling rainwater [ ] Early warning system
[ ] Hazard information [ ] Relocation of (hazardous) settlements
[ ] Land use planning [ ] Indigenous/traditional methods
[ ] Others (specify) ……………………..

33. What do you think would be the **most feasible** way to manage the risk of landslides in your village?

[ ] Gabions [ ] Masonry walls
[ ] Bioengineering [ ] Engineering (designed walls)
[ ] Drainage, channelling rainwater [ ] Early warning system
[ ] Hazard information [ ] Relocation of (hazardous) settlements
[ ] Land use planning [ ] Indigenous/traditional methods

[ ] Others (specify) ……………………..

34. Does your village receive any advanced information that a landslide may occur?

[ ] Yes [ ] No
[ ] Don't know [ ] No response

a. If yes, what information do you receive?

…………………………………………………………………… ……………………………………………………………………

b. If yes, who provides this information?

…………………………………………………………………… ……………………………………………………………………

c. If yes, has this information been useful to you?

…………………………………………………………………… ……………………………………………………………………

d. If yes, how have you used this information?

…………………………………………………………………… ……………………………………………………………………

35. In your opinion, what are the barriers to landslide risk management in your village?

[ ] Lack of awareness among h'hold level [ ] Lack of awareness among govt. auth'es
[ ] No government support [ ] No technical capacity
[ ] No budget (financial capacity) [ ] Lack of strategies, plans, guidelines
[ ] Others (specify) …………………………………………..

36. In your opinion, how should the guanpalika support your village with landslide risk reduction?

[ ] Assessing landslide hazard [ ] Providing information on landslide risk
[ ] Relocation of settlements/house [ ] Mitigation measures
[ ] Others (specify) …………………………………..

37. What is the best way to communicate information on landslide risk?

[ ] Posters, pamphlets, booklets, cartoons etc. [ ] Radio/TV (local, FM stations)
[ ] School curricula/formal education system [ ] Real models, demonstrations
[ ] Newspapers [ ] Families and friends
[ ] Social media [ ] Government (channels/auth'es)
[ ] Security forces (army/police) [ ] NGO/INGOs
[ ] Relief agencies [ ] Others (specify)……………………..
[ ] I don't know

38. Has landslide risk become more severe for your village since the 2015 earthquake?

[ ] Yes [ ] No [ ] Don't know

a. If yes, how? ………………………………………………………………………………………………………..

May I request your name? (if mentioned) ……………………………………………………………..
Do you have any questions about this survey? Or anything else to ask me?

Could you tell me about your family size and demographic structure?

Thank you very much for your time. **Namaste!**

Other remarks ………
………
………
………
………
………

Appendix 7. Guidance notes for enumerators for conducting household survey

Local perceptions and response to changing landslide risk following the 2015 Gorkha earthquake: Implications for effective risk reduction

Household survey questionnaire | Bhotekoshi Gaunpalika, Sindhupalchok District

Gopi K. Basyal | Durham University

Guidance notes for household survey

Introduction: Enumerator, the purpose of visiting this household
Consent: Ensure

Section A: Household profile

Question no.	**Guidance notes**
ID	Household survey ID
Date	Date of survey
Location	Location of survey (ward, tole, xy coordinates if possible – to map later)
Surveyor	Enumerator's ID
Consent	Please explain before starting the survey about the aim of the survey and possible time to be taken, get verbal consent from the respondent, and check the box.
Household head	This question asks about the official head of the household, that is, the main decision-maker in the family.
If not, who	If the respondent is not the head of the household, please clarify the respondent's relationship with the official head of the household.
Age/gender	Please clarify the respondent's age and gender
Marital status	Please clarify the marital status of the respondent. If 'other', specify.
Ethnicity	The ethnicity is based on Central Bureau of Statistics/Government of Nepal) classification. If not clear, specify.
Education	Level of education refers to the highest level of education completed. If the respondent is still studying, please clarify the highest level of education completed to date. • Non-literate – the respondent is unable to read or write • Basic literacy – the respondent can read and write but has not taken any formal education, can have simple reading/writing/calculating skills • Primary school completed – the respondent can read, write and calculate (up to grade 5) • High school completed (grade 10 completed) • Higher secondary school completed (grade 12 completed) • University level – BA/BSc degree completed or higher If the qualification is not listed, please specify under 'other'.

Question no.	Guidance notes
	• Technical college following high school completed (please mention CTEVT degrees completed, for example, Junior Overseer, Community Medicine Assistant (CMA, HA), etc.)
Hh size, family members	This question asks about family size, that is, number of people in the respondent's household, including hh head/interviewed. Please fill in the form by gender, specifying the age of each household member.
Occupation	Categorisation from Central Bureau of Statistics.
Decision	Who makes the important and final decisions in the household?
Length of stay in this place	For how long have this family been living in this place/village. The question is aimed at finding out about the social network as well as the understanding of local hazards. The respondents might be recent movers or have lived there from the ancestral period. The response might be either in years or from generations (mention clearly).
Reason for living	Such as from ancestral time, or children's education, business, shops, nearness to the workplace, safety etc. Some families have been displaced and may be staying temporarily in this place. Please make sure – if the householder stays permanently, sometimes they live in another place also. Some family members live in that place, and the rest of the family members live in the original place. Daily commuting, especially in a roadside location, is very much usual.
If displaced	Origin place and reason of displacement, mention previous address. And also mention how long this family has been living in this place. Mention only district gaunpalika and ward (anonymise).
Income (P)	Primary source of income. Stick to one main source of income, according to the family's opinion.
Income (S)	Secondary source of income (multiple sources could be possible), for example, remittances, running shops, daily labour, teaching in school, etc.
Rented or owned	Household ownership. Options are owned (by any member of the family), rented or others (specify).

Section B: Questions about current problems in the village and in particular landslides that have occurred

Question no.	Guidance notes
1	This question asks about the main problems faced by the villagers. Please ask the question as an open question and list the answers accordingly as given by the respondent. This question considers the unit as the village of residence of the respondent (where the survey is being undertaken). As an open question, enumerator not to influence answers. List the answers as the respondent gives them – multiple answers/inventory possible.
2	This question focuses on hazards and risk faced by villagers. Similar to the question above (#1). Please ask respondents (in general) the main hazards and

Question no.	Guidance notes
	risks the villagers face in this village (where the survey is being undertaken). This question focuses on the natural hazards and risks the villagers have to face. List the answers as in #1.
3	This question asks if landslides are a problem in the village (of the survey). Multiple choice answers: yes/no/don't know/others. If the answer is Yes, then go to #4.
4	This question intends to find out what kinds or types of landslide the respondents in the village experience. Possible answers might include rock falls, flow, creeping and other categories as understood by the respondent (specify). We can categorise later on accordingly. For your reference – we (among the team) can discuss the landslide types in general. *Landslide typology is given (Annex 1)*.
5	This is an open question and aims to obtain the respondent's independent view of the landslides in the village and their impact as experienced by villagers. Please list as described by the respondents, and list the impact in the past as much as possible (if any).
6	This question asks about the location of landslide occurrence in the village. If they are distributed, if possible, mention the name they have given and what kind of landscape, particular location or conditions that occur. If you have a map, plot these so they can be referred to during analysis.
6a	Ask the source of those landslide hazards if they are visible or if known by the respondent. If the respondent knows the source, please note them accordingly.
6b	This is a similar question to #6a; however, it asks why those landslides occur in such/those type of landscapes, places and conditions.
7	This question asks if the respondent can express the causes and trigger factors of landslides in his/her village. In what conditions do landslides start to occur, for example, heavy rainfall, road construction, earthquake etc.?
8	This question asks if the householder knows the particular season or timing of (the year) landslide occurrence in his/her village – month or specific week of the year. The intention is also to find out if his/her understanding resembles the actual occurrence period, very important for allotting time for preparedness.
9	This question asks if the householder understands in what kinds of conditions landslides start to occur, such as after heavy rainfall, after an earthquake, after continuous rainfall of 24 hours or 2 days of rain. If other conditions are identified by the respondent, please specify. These categories are helpful for further categorisation of the respondent's understanding.
10	This question asks about the respondent's knowledge/understanding of the landslide condition/risk within the village before the 2015 Gorkha earthquake and requests a comparison with the situation after the earthquake. Is landslide risk in the area more critical or reduced?

Question no.	Guidance notes
11	This is a comparison between the gaunpalika, the Upper Bhote Koshi Valley and Nepal to see if the respondent can compare the most problematic landslide areas and what he/she can explain about them. List the names of the places clearly and plot them on the map afterwards. Plotting will be impossible if the respondent mentions most landslide problems occur elsewhere in the country – in this case mention only the names as the respondent gives them (follow #11a, b and c).
11a	Within the gaunpalika.
11b	Within the Upper Bhote Koshi Valley.
11c	Within the whole of Nepal. If the respondent knows any landslide-prone (critical) areas within the country. This question explores how knowledgeable householder(s) are about landslide information/events happening in areas other than where they live (e.g. gaunpalika, Upper Bhote Koshi Valley and the entire country (Nepal)).
12	Asks about the reasons why areas become prone to landslides. List them as respondent gives them (as an inventory).
13	Has the landslide risk in these areas increased since the 2015 Gorkha earthquake?
13a	Within your village (if the respondents have a definite answer, that is, yes/no/don't know/no response).
13b	Within the gaunpalika – do--
13c	Within the Upper Bhote Koshi Valley – do--
14	This question asks for a comparison of the landslide risk between this year's (2018) monsoon and before the 2015 earthquake.

Section C: Questions about possible future landslides in the village

Question no.	Guidance notes
15	This is about the respondent's understanding of the possibility of future landslide occurrence in the village. As the respondent gives the answer, tick accordingly, yes, guaranteed/no/don't know/no response. No response sometimes means the respondent does not understand the subject matter being discussed.
16	If the answer to #15 is yes. Again, this is a probability question to understand how respondents feel about the possibility of landslides occurring in the coming 12 months. The response options range from certain to very unlikely (5-point likelihood). Please don't influence the respondent unnecessarily on the answer. Just facilitate them to understand the question as you ask. Make a simple way of expressing yourself when you ask the question.
16a	If the answer to #16 is yes, and the respondent thinks a landslide might occur. The types could be rock falls, flows, creeping or others as understood by the respondent. We can categorise accordingly at the later stage when we analyse.

Question no.	Guidance notes
16b	How big a landslide as in #16a
16c	The potential, likely impact as in #16b
17	Similar type of question to #16. This question asks how the respondent perceives the landslide risk within **five years**.
17a	The scale is the same as #16a
17b	The scale is the same as #16b
17c	The scale is the same as #16b
18	What does the householder understand about the direct impact of landslides on his/her house?
18a	If there could be a direct impact, how serious could it be – damage/destruction of house/other properties? Other impacts include chance of fatalities/death of a family member, injury, loss of land (farmland, agricultural land, land for crops), disruption to roads and trails (if this is to reach his/her house or farmland or other means of income, it can have a direct impact on the householder's economic situation). More indirect impacts are caused by disruption to utilities such as water and electricity. ****** when you are talking about fatalities, please be careful when mentioning the term death. It could hurt the family member if they have lost their family member in a previous earthquake or other incidents, especially in the 2015 Gorkha earthquake. Please deal with this question with maximum carefulness.

Section D: Questions about landslide risk reduction at the household level

Question no.	Guidance notes
19	Has the householder taken any measures to protect his/her house? This could be a simple assessment of ground conditions. Any preparedness measures should be noted, for example, check dams, gabions, structural and non-structural measures.
19a	If the answer to #19 is yes, mention the measures taken. If the answer is 'Others', specify.
19b	If not taken, why not? This could be a financial/economic/budget-related/technical problem. The householder may think the cost is very high and he/she cannot afford it, or it could be because he/she doesn't know the hazards and risks, source, etc.
20	If the householder has RECEIVED any technical support from anywhere with regard to landslide hazard risk management in relation to his/her house, mention/list.
20a	If RECEIVED, who has provided such technical support or assistance and whether this is completely or partially. Mention all of this on your answer sheet. Specify every answer so that it will be easy to categorise them later when we analyse responses later on. This is also an inventory of active actors in the village (if any), including government departments, gaunpalika engineers or technicians, DUDBC

Question no.	Guidance notes
	or DWIDP, private consultancies/contractors (even those who are active in hydroelectric power projects/road construction) in the valley or the Upper Bhote Koshi Valley as a whole.
21	This asks about the best way to manage landslide hazard risk as a household as he/she knows/thinks *(see detail for #22 guidance note, following row)*.
22	Do be aware of the distinction between best and feasible solutions. The best way might not be feasible for a household because of cost, lack of technical assistance. There is also a cost for an entire village, but government authorities would certainly not invest/spend a large amount of money to protect only one house. Collectively, villagers can have a better approach to and influence on the government authorities.
23	Can a householder protect his/her property from landslides?
23a	If the answer to #23 is yes, please ask how much or what percentage of household income can be spent on this, for example, one week's salary, one month' salary, etc. At the same time, there is a difference between the willingness to pay and the capability to pay. Make sure you understand the difference. Here we are concerned with how much the respondent can spend. Don't explain too much; it might confuse them.
24	When protecting house, what would be the most useful information about the landslide for the householder? The answer might include information about causes of landslides, size of landslide (because size could matter to his household – safety from landslide), timing of landslide (this matters if day/night, work/home, travel to farmland, jungle/stay in one place), season (may start occurring at the start of monsoon, some in the middle some at the end, or even after the monsoon). Thus, seasonality, the timing of the event, implies the safety of individual/community according to the time of landslide occurrence. Another key thing to remember is that most landslides occur during the monsoon, but the 2015 earthquake occurred in April, just before the monsoon started. Householders may understand/perceive the causes of landslides differently now than before (the earthquake) . Before the earthquake they would probably cite rain, road construction and development work. Now, they see the fragile landscape as a cause (became vulnerable after the big geohazard event). Additional information to note – warning signs of landslides (cracks formed, slow and fast movement of ground, tilting of trees, types of behaviour, etc.). The enumerator should be absolutely clear about the differences. And make sure that the response is correctly mentioned or categorised and noted in the questionnaire.
25	If the householder attended, mention any disaster risk management training in the past, including orientation, lectures, etc. *If yes, you can ask what the course was – list briefly when, what provided?*
26	Does the householder think the landslide risk became much more severe after the 2015 earthquake?
26a	If the answer to #26 is yes, how did the risk become more serious? Did the householder note new landslides, more frequent, timing of the landslide (pre- or

Question no.	Guidance notes
	post-monsoon) or any other understanding? Or, were there more fatalities, more disruption, more frequent disruptions, etc.

Section E: Questions about landslide risk reduction at the village level

Question no.	Guidance notes
27	This question explores whether villagers have (if) managed the landslides traditionally. It asks if the respondent knows the way landslides have been managed in the village – knowledge and practices acquired from older generations. For example, in many villages, there are (were) practices of managing drains before the monsoon and repairing trails, channels/drains, etc. in post-monsoon seasons, including *bhal-kulo*. Any other measures?
27a	The question asks if such practices are still continued in the villages and if the respondent knows about them.
27b	If the answer to #27 is yes, request examples they have been following (may need to give them some clues). The enumerator should listen attentively to explanations of traditional ways of mitigation. Note these carefully and don't miss any information.
28	Who does the respondent think is responsible for landslide risk management at the village level? The answers might include individuals, the gaunpalika, community groups (active at the village level), collaboration between community and the gaunpalika (to include both the ward and the local government body). For instance, budget (money) provided by the gaunpalika, implemented by user groups (*upabhokta samiti*). These exist widely in villages for conducting activities such as water supply and building retaining walls made of gabions. With regard to such activities (projects), from previous experience of conversations, several issues might arise, for example, the quality of construction (project), participation, transparency, inclusion, etc.
28a	The question asks if the householder also contributes to such initiatives/activities (this could include monetary contribution and labour).
28b	If the answer to #28a is yes, how? (answers might include attending meetings, giving advice, working with community groups, being a member of a user group or contributing money and/or labour for construction).
29	The question aims to find out if there is a formal structure for landslide risk reduction in the community, because this could result in a land use plan, a structural plan for walls or the formation of LDRMP/CDMCs in the village.
29a	If the answer to #29 is yes, request details.
30	This question asks if there are any measures taken for landslide protection in the village/community and if the respondent is aware of them.
30a	If the answer to #30 is yes, please ask him/her for details of the measures taken. These measures could be structural (gabions and masonry walls) as well as non-structural (awareness, planning, disaster preparedness and response plans, early

Question no.	Guidance notes
	warning systems, formation of community groups for landslide or disaster management).
30b	If not, why? Answers could be as follows: lack of technical support, other difficulties, technical feasibility, lack of awareness, lack of budget and sometimes difficulties in approaching the government/gaunpalika (this might also be of political interest). Some areas get much attention, and some get no attention at all (because rich people who live in some places may have better access to the seat of power and can influence the prioritisation of the budget – commonly happens). Certain political leaders may favour some areas (possibly to gain votes in an election, which is very common in Nepali scenarios). ***** sometimes, local ‘politics’ enter the equation. Be careful, deal safely.
31	Any external technical assistance received from any CBOs, NGOs, INGOs, local authorities or private consultancies (including hydroelectric power projects) with regard to managing landslides?
31a	If the answer to #31 is yes, then who has provided such assistance? Multiple answers are possible. Please do note as explained by the respondent. This will help us to find out who or what type of organisations/companies/actors are helping in the villages in a technical or non-technical sense with regard to DRR in general and landslide risk reduction in particular.
32	The question asks about the respondent’s understanding of the **best way** of managing landslide risk in the village. Be careful to note if this is for the village or household. The answers might be different from #31.
33	The **most feasible** way. There is a **difference between the best way and the most feasible way**. The best way means the most appropriate technologies. Here, the most feasible way refers to affordability at the local level, but affordability at the household, village, gaunpalika or government level (all of which could be classed as local) might be different. Enumerator: be clear about the difference between these two ideas.
34	This question asks whether information is circulated among villagers before landslide hazard events are about to occur, that is, early warning. Receiving information in advance could protect property and save lives. The information might be formal, informal or any other sort of information before the event (includes hazard maps, warnings and orientation/preparedness activities).
34a	If the answer to #34 is yes, what information, for example, hazard sources, rainfall intensity, possible landslide events, dangerous areas? Has the gaunpalika or any other organisation provided any information with regard to landslides (this is also a kind of early warning), that is, cracks, slumping, any indication of landslides? Be sure to note the answers to the latter.
34b	If the answer to #34 is yes, who are the providers: gaunpalika, scientists, hydroelectric power projects (active in the valley), villagers, family members who live in the high hills close to the hazard sources?

Question no.	Guidance notes
34c	If the answer to #34 is yes, has this information has been useful to you?
34d	If the answer to #34 is yes, how was the information used? For evacuation? Planning? Considerations in relation to house construction? Any other way?
35	This question asks about the barriers to landslide risk reduction villagers have faced at the village level. These include lack of awareness among householders, lack of government support, budget and technical support, no capability and poor quality of work.
36	This question asks how the gaunpalika should act towards the villages with regard to landslide risk reduction and seeks to explore villagers' expectations of the way landslide risk reduction should be handled or suggestions for how it should be tackled from their perspective. When asking this question, keep in mind structural and non-structural measures of landslide risk reduction at the village level. Options include landslide hazard assessment, information dissemination (early warning), relocation of vulnerable settlements as categorised by the (*paradhikaran*) National Reconstruction Authority (NRA) and other mitigation measures.
37	This question aims to identify the best way of communicating information on landslide risk to communities, which depends primarily on the severity and nature of hazards as perceived by villagers. The question has been designed to list and prioritise the best ways to use. Options include posters, radio and TV messages, booklets, real-scale demonstrations, for example, 3D models such as the shake table, street theatre, visuals, etc. When asking this question, note any mention of several earthquake risk communication tools that NSET have been using at the community and gaunpalika level such as scenario simulations, the shake table demonstration, etc.
38	Does the respondent think the severity of landslide risk has increased after the 2015 earthquake? Ask how the risk has changed in her/his view and experience after the 2015 earthquake as far as his/her own surroundings are concerned.
38a	List how it has changed, in the respondent's opinion and as experienced.

Appendix 8. Major themes for facilitating discussion among the participants during the live landslide demonstrations

Intervention themes	Description and basic elements covered to address the following issues
Understanding landslide hazards पहिरो प्रकोपबारे जानकारी	What do you think about why landslides occur? What do you think about where landslides occur? At what point, in what case/conditions, in what type of ground do landslides occur? Where is the risk of landslide in your area or in this model? तपाईंको बिचारमा पहिरो किन जान्छ?; कहाँ जान्छ?; कस्तो ठाउँमा, कस्तो अवस्थामा, जमीनमा जान्छ?; जोखिम कहाँ छ? आदि.
Risk perception जोखिम अवधारणा	Who knows the risks of landslides more? For instance, boys/girls (children), old people, teachers, people from outside (the village) or like us (outsiders, 'experts') or anyone else? Who is most concerned about the landscape of your village, for example, the ward (administration), village (means a community where you live), central authorities, gaunpalika (local authority called rural municipality) or who else? पहिरोको जोखिमका वारेमा कसलाई बढ्ता थाहा हुन्छ? जस्तै – केटा-केटी, बुढा-बुढी, शिक्षक, बाहिरबाट आएकाहरु – जस्तै हामी वा अरु कोहि? तपाईको गाउँको पहिरोको बारेमा कसलाई सबभन्दा बढी चासो हुन्छ? जस्तै: (वडा, गाउँपालिका केन्द्र? वा अरु कोहि?
Landslide risk जोखिम वुझाई	What is the extent of potential damage in your village due to landslides (range of answers from not at all to a great deal)? How do you define the possible loss in future due to landslides that might occur in your village (meaning community) and its surroundings? What damage is relatively greater (impact) that in your opinion can severely affect your family or community? This includes villagers' livelihoods (livestock, farming, schools, local roads and infrastructure). तपाईको गाउँको पहिरोले सम्भावित क्षतिको मात्रा कति छ? छँदै छैन ..... धेरै छ; तुलनात्मक कुनखाले क्षति बढी हो? मानिस (जीऊ-ज्यान), बस्तुभाउ, खेतिपाती, विद्यालय, सडक आदि?
Mitigation रोकथाम वा जोखिम न्यूनीकरणका उपायहरु	What measures should be taken to prevent or mitigate risk? What can be done, are the measures technically or financially feasible? Who should undertake them? What we can do? पहिरो रोकथाम वा जोखिम न्यूनीकरणका लागि के उपायहरु गर्नुपर्छ? ; के गर्न सकिन्छ?; कसले गर्नुपर्छ?
Demonstration	We expect your reflections and opinions on the following:

Intervention themes	Description and basic elements covered to address the following issues
नमूना मोडेल	Will the model help explain the above-mentioned issues? How useful is this message given through the model? What can be done to improve the model? के मोडेल ले माथि भनिएका कुराहरु बुझाईमा मद्दत गर्ला?; यसले दिने सन्देश कति उपयोगि होला? ; सुधारका लागि के गर्नुपर्ला? के ठिक लाग्यो, के ठीक लागेन, के गरेको भए हुन्थ्यो? । तपाईंले यो मोडेल हेर्नु पहिले र हेरि सकेपछी केहि नयाँ थाहा पाउनु भयो? वा तपाईंलाई थाहा भएको भन्दा केहि थपिएन? । के छुट्यो? देखाउनै पर्ने, के थप्नु पर्छ भविष्यमा? ।के उपयोगि छ? । के सवै दर्शकलाई यहि मोडेल, नमूना उपयुक्त होला? वा दर्शक अनुसार फरक गर्नुपर्ला? । दर्शकहरु, को को लाई देखाउनै पर्ला? (शिक्षक, विद्यार्थि, गाउँले, गाउँपालिका सदस्यहरु, अन्य................) । के देखाउनु पर्ला?

Appendix 9. Questions guiding discussion/feedback on the live landslide demonstrations

SN	Interaction/feedback themes	Description and basic elements covered during the feedback session
1	Your impression of the model मोडेल सम्बन्धी तपाईंको प्रत्यक्ष प्रभाव-अनुभव	Usefulness, physical attractiveness of the model, overall doability, makes sense or not, do you suggest making this model similar to the shake table? मोडेल कस्तो लाग्यो, यसको उपयोगिता, आकर्षण, समग्र कार्य-क्षमताका बारेमा उल्लेख गरिदिनु होला?
2	Your thoughts on the message as explained during the demonstration यहाँ दिईएका सन्देशहरु, बर्णन गरिएका कुराहरु बारे तपाईंको प्रतिक्रिया	Does it help you to understand the message in terms of the landslide process, the associated hazards and risks, and mitigation measures? मोडेलमा दिईएको सन्देशमा पहिरो- भूस्खलन प्रक्रिया, प्रकोप - खतराहरू, जोखिम र रोकथाम तथा जोखिम न्यूनिकरणका पक्षहरू बुझ्न केहि मद्दत गर्दछ? सन्देस पर्याप्त छ?
3	Suggestions for improvement सुधारको लागि तपाइँको सुझाव	Model, demonstration process, message delivered. मोडेल, प्रदर्शन प्रक्रिया, सन्देश दिने तरिकाहरुमा यहाँको सुझाव.
4	Additional comments कुनै पनि अन्य प्रतिक्रिया	Nepal's context, language, technicality, psychological state of householders living with landslide risk. कृपया तपाईलाई लागेको कुनै पनि टिप्पणी थप्न स्वतन्त्र हुनुहुन्छ; जस्तोकि सन्दर्भ, भाषा, प्राविधिकता, पहिरो जोखिममा रहेका घरपरिवारको अन्य पक्ष र अन्य.
5	Other remarks अन्य प्रतिक्रियाहरु	Open remarks, if any.

Appendix 10. Summary of audience responses to the landslide demonstrations

This table below is a collection of some of the written responses to the landslide demonstrations, reproduced here with the consent of the participants.

Respondents/Location	**मोडेलका वारेमा तपाईंको प्रत्यक्ष प्रभाव-अनुभव:** *(मोडेल कस्तो लाग्यो, यसको उपयोगिता, आकर्षण, समग्र कार्य-क्षमताका बारेमा उल्लेख गरिदिनु होला)*
	Your impression on the model: *(Usefulness, physical attractiveness of the model, overall doability, makes sense or not, do you suggest making this model similar to the shake table?)*
१	मोडेल असाध्यै राम्रो लाग्यो. जसले हाम्रो भू-स्वरुपलाई जिउँका तिउँ, जस्ता को त्यस्तै चित्रण गरेको पाईयो. मोडेल प्रदर्शनले भयावह स्थिति नल्याउँदै त्यसको रोकथाम तथा वैल्पिक उपायहरु अपनाई धनजनको क्षति हुनबाट बच्न सकिने सन्देश प्रबाह गरेको छ. भूस्वरूपको नमूना निर्माण र प्रस्तोता-सरको प्रभावकारी प्रदर्शनले उक्त समय भर महत्वपूर्ण जानकारीहरुको साथसाथै समुदायका मानिसहरु बिच जम्काभेट, कुराकानीले कार्यक्रम रोचक पनि रह्यो.
1: (Chaku)	The model looks great. On which we found our landscapes are represented very much like living things (realistic). Model performance has conveyed the message that prevention is better before the start and the loss due to landslides can be avoided by taking preventative and alternative measures without fearful consequences. The ground breaking in the model has been impressive display of the model by presenters along with the valuable information conveyed throughout the time. In addition, the interaction between the people [presenters, experts] and the community [members] made the [interaction] interesting.
२	सर्वप्रथम मलाई यो मोडेल एकदमै राम्रो लाग्यो. किनभने हामीले जतिपनि यो प्राकृतिक प्रकोपको बारेमा अध्ययन गर्‍यौं. त्यो मात्र सुनाईमा रहन्थ्यो, हालको यो जुन प्रकारको देखाई बुझाईका लागि तपाईहरुले देखाउनु भयो. यो बाट हुने प्रभाव, असर, त्यसका न्युनीकरण गर्ने उपाय, रेखदेखबारे पनि हामीलाई यसले थप ज्ञान प्रदान गर्यो. किनभने जुन कुरा आफूले देखेको हुन्छ त्यो कहिल्यै विर्सेर जाँदैन. यसले मानिसलाई थप ज्ञान दिन्छ, यसरी नै तपाईहरुले अन्य विद्यालय, टोल, छिमेक, गाऊँ गाऊँमा गएर त्यसको प्रत्यक्ष असर र जुन कुरा हामीमा गर्नु भयो त्यो सवैमा गरिदिनु होला. यसरी समाज नै परिवर्तन हुन सक्छ. र यसमा तपाईप्रति मेरो पनि पुन: सक्दो सहयोग रहने छ.
2: (Chaku)	First of all, I liked this model very well. Because everywhere we [spoke] about this [natural] disaster. [But] it was just a matter of hearing [listen from them], [instead] currently you showed it to us with explanation [you explained]. It also gave us more insight into the effects [of landslides], ways to minimise [its impacts] it and how to look after it. Because what we saw in it will never be forgotten. It gives people more knowledge, so you can go to other schools, toles, neighbourhoods, villages, and tell them which will have a direct impact on them [which you did for us here]. This is how society can change itself. And, I will be trying my best to help you again.

	३	मोडेल बिभिन्न जोखिमपुर्ण ठाउँहरुलाई त्यसका असर हेरी न्यूनीकरण गर्न सकिने र यस्ता जोखिमपुर्ण समस्याको विकल्प खोजेर यसको समाधान तथा यसबाट जोगिन सकिने खालको मोडेल थियो. यसबाट हामीले यस्ता जोखिमपूर्ण समस्याहरु बाट जोगिने जनचेतना प्राप्त गर्न सक्यौं.
	3	The model displayed the message effectively that the various risky places could be mitigated by finding alternatives to such risky problems and avoiding them. Through this, we can raise awareness of such problems of landslide risk areas.
	४	पहिरोको मोडेल राम्रो छ.यहाँहरुले अनुभव गर्नु भएको र प्रत्यक्ष रुपमा हजुरहरुले आफ्नै आँखाले देखेर मोडेल बनाएको अन्य ठाउँमा पनि देखाउन सके बेसहोला.
	4	The model [representation] of the landscape is good. Here you can see the experience that you have seen directly and with your own eyes, and you can model it in other places.
	5	the model demonstration was very useful in conveying a specific type of landslide mechanism (slide) like the landslide in Yarsa VDC Rasuwa district (Thangdor). It showed us warning signs of landslides like – long cracks developed at the top of landslides; the tilting of electric or telephone poles; inclination of trees from normal position, etc. It shows that people living in places far away from cracks might be vulnerable as well, and highlights importance of careful observations from local community to monitor landslides, so the model is very useful. The model is physically attractive and doable. This model is very useful and fruitful for its purpose. To make this model similar to shake table (and compare two identical models, one with applied mitigation measures, the other without, adding overhanging rocks, boulders, etc. that may fall during landslides).
	6	The model and the failure pattern of land (scape) made good sense and it demonstrated well how a landslide progresses. In terms of the attractiveness of the model, it was not bad. Considering the amount of effort it takes to make the model, it looked good. Yes, it would be great if we could see other modes of the landslide as well.
	7	Yes, the model very useful in the context of Nepal with diversified topography, and it has made a remarkable sense of understanding landslides with little difference from the natural phenomena. If possible we should try to make a model like the shake table.
	8	I found the demonstration model very useful for the public and even for the community leaders.

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