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On Landslide Risk, Resilience and Vulnerability of Mountain Communities in Central-Eastern Nepal

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On Landslide Risk, Resilience and Vulnerability of Mountain Communities in Central-Eastern Nepal

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par

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Dedication

To Lilian Sudmeier (1940 – 2007).

Acknowledgements

Completing a PhD thesis at the age of forty-five is not the same as completing one in your twenties. As a mother of two daughters, I realize that many of my family members were quite concerned about me when I travelled to landslide prone areas of Pakistan and Nepal and I thank them for their patience. The challenge, experience and motivation of embarking on a PhD in your forties are perhaps stronger but then so are the daily time constraints: homework, taking kids to piano lessons, etc. Writing acknowledgements is also not an easy task when you have already been through half of your life. There are so many people to thank, starting with my parents Lilian Sudmeier, Dr. James Sudmeier, and brother John Sudmeier without whom I wouldn't be who I am. They put me on the right track, funded my early studies, infused in me a love of learning and a good dose of stubbornness. My husband Eric Rieux deserves a medal for tolerating my many long years of studies and travels away from home during which he had to bear all the childrearing and household tasks. My girls Sonia and Mona were brave to be without their mother for such long periods of time, not always understanding why I had to be gone for so long.

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Acronyms

CA	Constituent Assembly
CBDRR	Community Based Disaster Risk Reduction
CCA	Climate Change Adaptation
CF	Community Forest
CFUG	Community Forest User Group
DDC	District Development Committee
DEM	Digital Elevation Model
DFID	Department for International Development (U.K.)
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWIDP	Department of Water Induced Disaster Preparedness
GAR	Global Assessment Report (UNISDR)
GIS	Geographical Information System
GPS	Geographical Positioning System
HFA	Hyogo Framework for Action
ICIMOD	International Center for Integrated Mountain Development
INGO	International Non-Governmental Organisation
IPCC	Intergovernmental Panel for Climate Change
IUCN	International Union for Conservation of Nature
NGO	Non-Governmental Organisation
NLSS	Nepal Living Standards Survey
NPR	Nepal Rupees
NSCFP	Nepal-Swiss Community Forest Project
SDC	Swiss Development Cooperation
SLA	Sustainable Livelihoods Approach
SNSF	Swiss National Science Foundation
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
VDC	Village District Committee

Nepali terms used:

Bari	Irrigated terraces
Khet	Rainfed terraces
Pahiro	Landslide

Executive Summary

In Nepal, landslides are one of the major natural hazards after epidemics, killing over 100 persons per year. However, this figure is an underreported reflection of the actual impact that landslides have on livelihoods and food security in rural Nepal. With predictions of more intense rainfall patterns, landslide occurrence in the Himalayas is likely to increase and continue to be one of the major impediments to development. Due to the remoteness of many localities and lack of resources, responsibilities for disaster preparedness and response in mountain areas usually lie with the communities themselves. Everyday life is full of risk in mountains of Nepal. This is why mountain populations, as well as other populations living in harsh conditions have developed a number of coping strategies for dealing with adverse situations. Perhaps due to the dispersed and remote nature of landslides in Nepal, there have been few studies on vulnerability, coping- and mitigation strategies of landslide affected populations. There are also few recommendations available to guide authorities and populations how to reduce losses due to landslides in Nepal, and even less so, how to operationalize resilience and vulnerability.

Many policy makers, international donors, NGOs and national authorities are currently asking what investments are needed to increase the so-called 'resilience' of mountain populations to deal with climate risks. However, mountain populations are already quite resilient to seasonal fluctuations, temperature variations, rainfall patterns and market prices. In spite of their resilience, they continue to live in places at risk due to high vulnerability caused by structural inequalities: access to land, resources, markets, education. This interdisciplinary thesis examines the concept of resilience by questioning its usefulness and validity as the current goal of international development and disaster risk reduction policies, its conceptual limitations and its possible scope of action. The goal of this study is two-fold: to better define and distinguish factors and relationships between resilience, vulnerability, capacities and risk; and to test and improve a participatory methodology for evaluating landslide risk that can serve as a guidance tool for improving community-based disaster risk reduction. The objective is to develop a simple methodology that can be used by NGOs, local authorities and communities to reduce losses from landslides.

Through its six case studies in Central-Eastern Nepal, this study explores the relation between resilience, vulnerability and landslide risk based on interdisciplinary methods, including geological assessments of landslides, semi-structured interviews, focus groups and participatory risk mapping. For comparison, the study sites were chosen in Tehrathum, Sunsari and Dolakha Districts of Central/Eastern Nepal, to reflect a variety of landslide types, from chronic to acute, and a variety of communities, from very marginalized to very high status. The study uses the Sustainable Livelihoods Approach as its conceptual basis, which is based on the notion that access and rights to resources (natural, human/institutional, economic, environmental, physical) are the basis for coping with adversity, such as landslides. The study is also intended as a contribution to the growing literature and practices on Community Based Disaster Risk Reduction specifically adapted to landslide- prone areas.

In addition to the six case studies, results include an indicator based methodology for assessing and measuring vulnerability and resilience, a composite risk assessment methodology, a typology of coping strategies and risk perceptions and a thorough analysis of the relation between risk, vulnerability and resilience. The methodology for assessing vulnerability, resilience and risk is relatively cost-effective and replicable in a low-data environment. Perhaps the major finding is that resilience is a process that defines a community's (or system's) capacity to rebound following adversity but it does not necessarily reduce vulnerability or risk, which requires addressing more structural issues related to poverty. Therefore, conclusions include a critical view of resilience as a main goal of international development and disaster risk reduction policies. It is a useful concept in the context of recovery after a disaster but it needs to be addressed in parallel with vulnerability and risk.

This research was funded by an interdisciplinary grant (#26083591) from the Swiss National Science Foundation for the period 2009-2011 and a seed grant from the Faculty of Geosciences and Environment at the University of Lausanne in 2008.

Résumé en français

Au Népal, les glissements de terrain sont un des aléas les plus dévastateurs après les épidémies, causant 100 morts par an. Pourtant, ce chiffre est une sous-estimation de l'impact réel de l'effet des glissements sur les moyens de subsistance et la sécurité alimentaire au Népal. Avec des prévisions de pluies plus intenses, l'occurrence des glissements dans les Himalayas augmente et présente un obstacle au développement. Du fait de l'éloignement et du manque de ressources dans les montagnes au Népal, la responsabilité de la préparation et la réponse aux catastrophes se trouve chez les communautés elles-mêmes. Le risque fait partie de la vie quotidienne dans les montagnes du Népal. C'est pourquoi les populations montagnardes, comme d'autres populations vivant dans des milieux contraignants, ont développé des stratégies pour faire face aux situations défavorables. Peu d'études existent sur la vulnérabilité, ceci étant probablement dû à l'éloignement et pourtant, les stratégies d'adaptation et de mitigation des populations touchées par des glissements au Népal existent.

Beaucoup de décideurs politiques, bailleurs de fonds, ONG et autorités nationales se demandent quels investissements sont nécessaires afin d'augmenter la 'résilience' des populations de montagne pour faire face aux changements climatiques. Pourtant, ces populations sont déjà résilientes aux fluctuations des saisons, des variations de température, des pluies et des prix des marchés. En dépit de leur résilience, ils continuent de vivre dans des endroits à fort risque à cause des vulnérabilités créées par les inégalités structurelles : l'accès à la terre, aux ressources, aux marchés et à l'éducation. Cette thèse interdisciplinaire examine le concept de la résilience en mettant en cause son utilité et sa validité en tant que but actuel des politiques internationales de développement et de réduction des risques, ainsi que ses limitations conceptuelles et ses possibles champs d'action. Le but de cette étude est double : mieux définir et distinguer les facteurs et relations entre la résilience, la vulnérabilité, les capacités et le risque ; Et tester et améliorer une méthode participative pour évaluer le risque des glissements qui peut servir en tant qu'outil indicatif pour améliorer la réduction des risques des communautés. Le but est de développer une méthodologie simple qui peut être utilisée par des ONG, autorités locales et communautés pour réduire les pertes dues aux glissements.

A travers les études de cas au centre-est du Népal, cette étude explore le rapport entre la résilience, la vulnérabilité et les glissements basée sur des méthodes interdisciplinaires ; Y sont inclus des évaluations géologiques des glissements, des entretiens semi-dirigés, des discussions de groupes et des cartes de risques participatives. Pour la comparaison, les zones d'études ont été sélectionnées dans les districts de Tehrathum, Sunsari et Dolakha dans le centre-est du Népal, afin de refléter différents types de glissements, de chroniques à urgents, ainsi que différentes communautés, variant de très marginalisées à très haut statut. Pour son cadre conceptuel, cette étude s'appuie sur l'approche de moyens de subsistance durable, qui est basée sur les notions d'accès et de droit aux ressources (naturelles, humaines/institutionnelles, économiques, environnementales, physiques) et qui sont le minimum pour faire face à des situations difficiles, comme des glissements. Cette étude se veut aussi une contribution à la littérature et aux pratiques en croissantes sur la réduction des risques communautaires, spécifiquement adaptées aux zones affectées par des glissements.

En plus des six études de cas, les résultats incluent une méthodologie basée sur des indicateurs pour évaluer et mesurer la vulnérabilité et la résilience, une méthodologie sur le risque composé, une typologie de stratégies d'adaptation et perceptions des risques ainsi qu'une analyse fondamentale de la relation entre risque, vulnérabilité et résilience. Les méthodologies pour l'évaluation de la vulnérabilité, de la résilience et du risque sont relativement peu coûteuses et reproductibles dans des endroits avec peu de données disponibles. Le résultat probablement le plus pertinent est que la résilience est un processus qui définit la capacité d'une communauté (ou d'un système) à rebondir suite à une situation défavorable, mais qui ne réduit pas forcement la vulnérabilité ou le risque, et qui requiert une approche plus fondamentale s'adressant aux questions de pauvreté. Les conclusions incluent une vue critique de la résilience comme but principal des politiques internationales de développement et de réduction des risques. C'est un concept utile dans le contexte de la récupération après une catastrophe mais il doit être pris en compte au même titre que la vulnérabilité et le risque.

Cette recherche a été financée par un fonds interdisciplinaire (#26083591) du Fonds National Suisse pour la période 2009-2011 et un fonds de préparation de recherches par la Faculté des Géosciences et Environnement à l'Université de Lausanne en 2008.

Introduction

1.1 Background

Mountain populations, as well as other populations living in harsh conditions have developed a number of coping strategies for dealing with adverse situations such as epidemics, crop failures, landslides and flash floods as part of their everyday livelihood strategies. While hazards are triggered by physical events, disasters result from a society's incapacity to manage nature's destructive forces. This incapacity can be due to the sheer magnitude of a hazard event, but is most often rooted in vulnerability, poor development, poor governance, and above all, a lack of sustainable livelihoods options. Hazards in mountains can be especially devastating: landslides change landscapes permanently, drought or frost is common, flash floods, avalanches or Glacial Lake Outburst Floods (GLOF)s come without warning and "cloud bursts" in Nepal are especially devastating. Many policy makers, donors, NGOs and national authorities are currently asking what investments are needed to increase the so-called "resilience" of mountain populations to deal with climate risks. However, mountain populations are already quite resilient to the ups and downs of the seasons, temperature variations, rainfall patterns and market prices. In spite of their resilience, they continue to live in places at risk due to high vulnerability caused by structural inequalities: access to land, resources, markets, education. This study examines the concept of resilience by questioning its usefulness as the ultimate goal of international disaster risk reduction and climate change policies, its limitations and its possible scope of action. Through its six case studies, this study also explores root causes of landslide risk, as resulting from a combination of vulnerability, exposure and hazards and how these notions relate to resilience.

Nepal is considered a hotspot for disasters and poverty and a natural place for studying landslides. The country has over 900 fatal disasters on average yearly and is considered one of the most disaster affected countries in the world (Harmeling, 2010; MoHA, 2009). Disasters make it difficult for this landlocked country to achieve Millennium Development Goal objectives. According to statistics of disaster losses in Nepal during 1971-2006, landslides caused the greatest number of casualties (3,899), after epidemics (15,529) or over 100 fatalities annually (NSET, 2011) (Figure 1) . In addition, landslides carry away homes and fields, which may not be recoverable. Most landslides in remote areas are not reported as most are small shallow landslides affecting livelihoods.

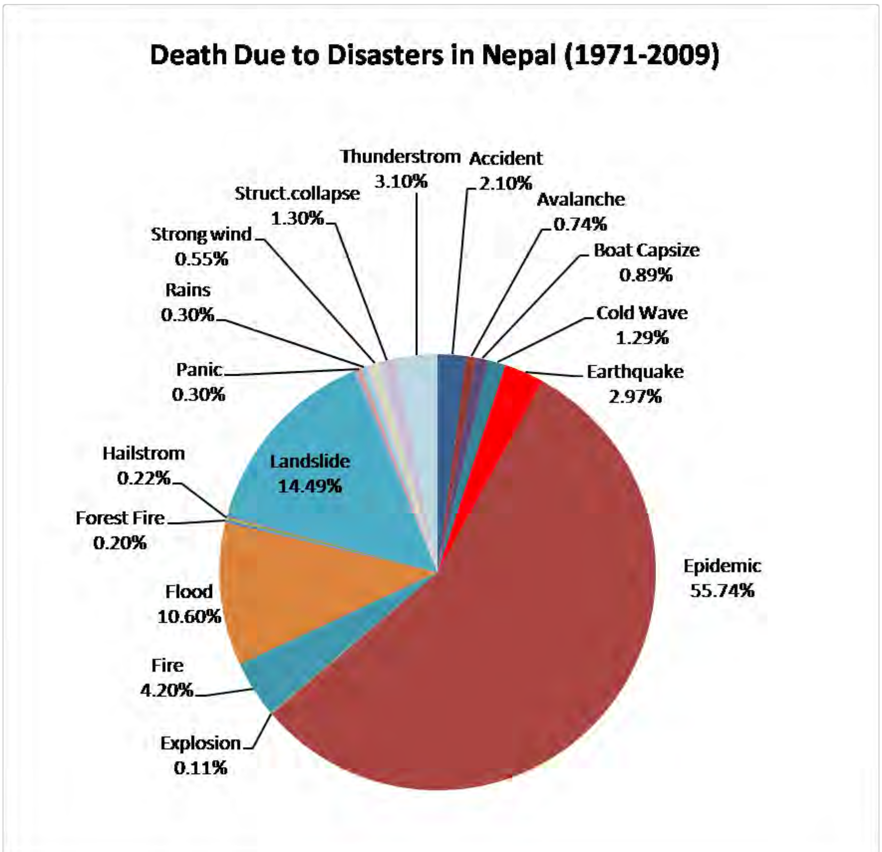


Figure 1. Casualties due to disasters in Nepal by type of disaster 1971-2009 (from NSET, 2011)

The cause of landslides in Nepal, whether due to human agency or naturally occurring, has been subject to debate over the past decades since Eckholm (1975) published the "great Himalayan Tragedy", claiming that deforestation by Nepali farmers was the main cause of erosion and consequently flooding in the Ganges basin. Subsequent studies by Ives and Messerli, (1989) provided evidence to disclaim Eckholm's theory, stating that landslides and erosion on the contrary, are mainly naturally occurring events. Other authors, notably Laban (1979), Ramsey (1987), and more recently Petley et al. (2007) provide a more balanced view: human agency, mainly road building and land degradation, are most likely responsible for approximately half of all landslides, especially shallow landslides. Shallow landslides (< 1-5 m deep) are also the most commonly occurring; they are underreported and severely affect the rural population and their livelihoods by destroying terraces and homes.

Partly as a consequence to this debate , the dispersed nature of landslides in remote areas and competing needs for disaster risk reduction, little interest has been paid to addressing the problem of landslides in Nepal. Yet two factors make it very likely that the occurrence of landslides will continue to increase. Scientific data, models and farmer observations already confirm that monsoon rainfall patterns are intensifying into a shorter monsoon period (Baidya & Sheikh, 2008; Borgatti & Soldati, 2010; MoHA, 2009; Petley, 2010). These trends have already resulted in an increased magnitude and frequency of water-induced disasters: landslides, debris flows and flooding (Shrestha and Devkota, 2010). Secondly, the decentralization that has taken place since the new government was formed in 2008 has given new powers to district and village level authorities. New local roads are now being built by communities, villages and districts, most often without oversight by the Nepal Road Department. Most frequently, these roads are being bulldozed in the dry season and washed out in the rainy season, with high risk of increased landslides. This emphasis on road building reflects popular demand for increased connectivity and access to the economic opportunities and amenities that roads and urban centers bring. Popular demand is not necessarily for physical security, as reflected by a very different attitude to physical risk, such as riding on top of buses or the complete lack of seatbelts. Thus risk in the Nepal context has a different connotation.

This different notion of risk, as perceived by most mountain populations, is why a word of caution is required before embarking on a study of resilience, risk and vulnerability. Main concerns of a majority of the population are food security, improved livelihood opportunities, education, prioritized ahead of concerns about flood or landslide risk. According to Cannon (2008), "Outsider's interventions have often ignored people's own grass roots hierarchy of risks. Based on 100s of IFRC vulnerability assessments, a clear pattern emerges that communities have a different set of priorities to those of outsiders who want to help protect them from extreme risks". Is the concern with disaster and climate risks misplaced, considering that a majority of deaths are due to easily treated diseases, such as diarrhea? As Bankoff (2001) states, Western development discourse has cast developing countries as first 'primitive' then 'vulnerable' and in need of 'relief'. Another word of caution is needed regarding the emphasis on 'extreme events', or 'intensive risk' brought by the new paradigm of climate change and resilience versus 'extensive risk', or high frequency, cumulative risk (Gaillard et al., 2010; UNISDR, 2011). Is this emphasis on climate risks and the extreme truly the issue at hand as the climate change lobby would have us believe, or is the issue rather addressing poverty alleviation and exposure of people living in dangerous places (Kelman and Gaillard, 2008)?

Recent data from UNISDR (2011) suggest that main drivers of disasters risk is inappropriate land use planning, ecosystem decline and poverty. Climate change was mentioned as a driver of risk in the 2009 Global Assessment of Risk (GAR) but is downplayed in GAR 2011, rather emphasizing the above-mentioned drivers. This study, although promising to develop an operational framework for assessing resilience, based on the high demand for such tools for guiding interventions for reducing landslide risk, takes a critical view of the role and place of resilience versus the emphasis that should be placed on vulnerability and risk reduction. Based on these issues as discussed above, we have formulated the following problem statement, research objectives, hypotheses, research questions and specific outputs for this study:

1.2 Problem statement

Resilience is increasingly used as the goal of disaster risk reduction policies and practices but the concept is poorly defined and difficult to operationalize. There are few studies that provide clear definitions of terms and improve our understanding of the relationship between the terms vulnerability, capacities, risk and resilience. Secondly, due to the dispersed and remote nature of landslides in Nepal, there have been few studies on vulnerability, resilience, coping capacities and mitigation strategies for landslides. There is currently increasing attention being paid to mountain hazards in Nepal and mounting interest in incorporating disaster risk reduction measures in local development plans. However, there are also few recommendations available to guide authorities and populations how to reduce losses due to landslides in Nepal.

This problem statement led to the development of general research questions followed by specific research questions.

1.3 General research questions

1. What is resilience of mountain communities to landslides?
2. What is resilience versus vulnerability and capacities?
3. Is it possible to measure resilience and vulnerability?
4. What are causal factors of landslide risk for mountain communities in Eastern Nepal?

1.4 Specific research questions

On landslides:

i. Who is being impacted by landslides?
ii. How are people impacted by landslides?
iii. How do households perceive landslide risk?
iv. What are local coping strategies to landslides?
v. What is being done by households, communities and authorities to mitigate landslides?

On resilience and vulnerability:

i. What is resilience and vulnerability to landslides and how can this be measured?
ii. To what extent is resilience different from vulnerability or just its direct opposite?
iii. Which are the main factors of vulnerability and resilience that have the greatest impact on a community's ability to cope and mitigate landslide risk?

These research questions then enabled the formation of three research objectives:

1.5 Research objectives

The objective of this study is three-fold:

1. To define and distinguish factors and relationships between resilience, vulnerability, coping strategies and risk as a basis for improving community-based disaster risk reduction strategies for landslide affected communities in Eastern Nepal;

2. To develop an operational framework for measuring resilience and vulnerability as a guidance tool for directing interventions for reducing landslide risk in central and Eastern Nepal;

3. To test and improve a participatory methodology for evaluating landslide risk: coping strategies, risk perceptions and causal factors of vulnerability for landslide affected communities.

1.6 Hypotheses

a) Resilience can be both a process and an outcome that defines the end of a disaster recovery period. It is largely synonymous with coping capacities, or the resources required to return to pre-disaster conditions.
b) Its usefulness is limited to the recovery period for risk management, but it does not necessarily reduce vulnerability or risk. Vulnerability and capacities are more useful terms to describing the long-term process

required to address improved livelihood access and resources, which is the most effective way for sustained risk management.

c) Causal factors of resilience are mainly linked to access and rights to sustainable livelihoods resources, namely economic, social, physical, environmental and human/institutional resources.

d) It is possible to measure resilience based on the above identified causal factors.

1.7 Specific outputs of this study include:

- Development of community based risk and resilience index
- Development of a typology of coping responses and risk perceptions
- Policy recommendations for reducing losses from landslides in Eastern Nepal.

Before getting to Chapter 2 and the Nepal context, the following section describes the genesis of this research, justifies why these sites were selected, a brief description of each site and how the research evolved, using an iterative approach to research.

1.8 Selection of study sites – rationale and general description

The first principle guiding this research is its iterative nature, which became the default operational mode of this research project due to personal time constraints, i.e. family obligations set a time limit of a maximum of two-three weeks in the field and 2 to 3 times per year. Fortunately, the grant obtained from the Swiss National Science Foundation (SNSF), interdisciplinary section, was generous enough to allow for multiple travels. However, rather than seeing this time constraint as a negative impediment to this research project, it became a positive one as it allowed for theoretical reflection, data analysis, and methodological performance in between each field trip.

1.8.1. Research in Pakistan 2006-2007

This research first began before officially starting the PhD program at the University of Lausanne when employed as a consultant at the International Union for Conservation of Nature (IUCN) to explore the role of ecosystems for disaster risk reduction because of my background in forestry and international development. Funding was obtained from the Geneva International Academic Network to research linkages between forest cover and shall landslides in Kashmir, Northern Pakistan in 2006-2007 (Sudmeier-Rieux et al., 2011a) during which two field trips 20 days long were undertaken. When signing up for the PhD program at the University of Lausanne, it became clear that an interdisciplinary and integrated approach to exploring and addressing landslide risk was necessary and under researched.

Lower Neelum River Valley was selected upon the recommendation of our host organization, the International Union of Conservation of Nature (IUCN) - Pakistan for its relatively easy access (9km of treacherous dirt road above a cliff) its two very distinct river banks and because this was the location of the earthquake epicenter (34.493°N, 73.629°E) (Owen et al., 2008) (Figure 2). The area studied is 381 km^2, with a population density of 264 persons/km^2 (AJK Planning Dept., 2005). The lower Neelum River Valley is a west–east-oriented steep V-shaped valley with an estimated slope range of

35–65°, an average width of 15 km, and an altitude range of 800–3000 m. The average annual rainfall is 1527 mm and can be especially intense during the monsoon months, July and August, with as much as 100 mm during 1 single event (AJK Planning Dept., 2005). The southwest-oriented right bank is mainly privately owned and has been converted into pasture fields and terrace agriculture, while the northeast left bank remains largely forested. The left bank has fewer villages and only a few roads, mainly along the river bed. This largely forested area is to a greater extent state owned, with few private and communal lands, or *shamilat.* The two villages that were selected for a study of the social context are Saidpur and Kohori villages in Neelum River Valley, whose economy is predominately based on subsistence farming, fruit harvesting, animal husbandry and remittances. Unfortunately, the political situation in Pakistan deteriorated after 2008, making it no longer possible for any teams from the University of Lausanne (UNIL) to continue work in this area. The Pakistan work is covered in section 2.2.

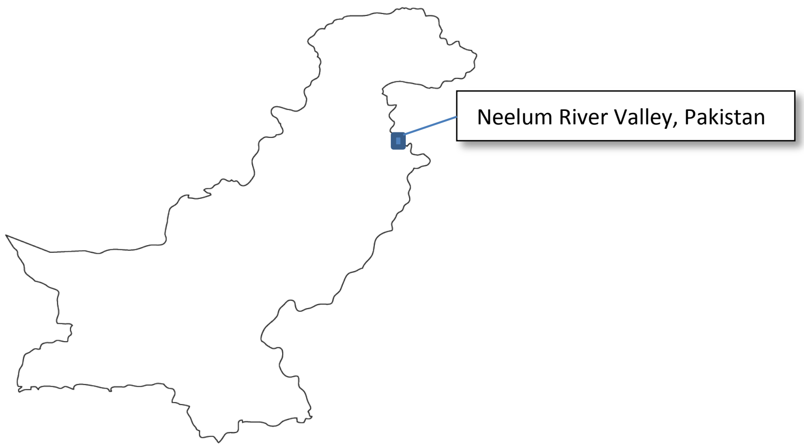


Figure 2. Outline map of Pakistan, indicating study site area, Neelum Valley, Azad Kashmir and Jammu, Pakistan

1.8.2. Research in Sunsari and Tehrathum Districts 2008-2009

Research sites in Sunsari and Tehrathum districts were selected based on knowledge of these areas by our host organization, IUCN – Nepal (Figure 3). Several villages were visited during a first exploratory field trip, which was organized and funded by the Faculty of Geosciences and Environment at UNIL in 2008. A first two-week long field trip was organized by IUCN Nepal to the Dharan region of Eastern Nepal for a team of three persons, two Masters students, Jerôme Dubois and Alain Breguet in geology and myself from the UNIL, Institute of Geomatics and Analysis of Risk (IGAR). Several research sites were selected together with IUCN Nepal, based on their knowledge of several landslide affected communities, accessibility by road and safety issues. These sites were Katahare village, east of Dharan, Punarbas Township downstream from Katahare, Tamarkam village above Dharan municipality and Sabra village, 90km north of Dharan, as this was the place where IUCN Nepal had been conducting a Swiss Development Cooperation (SDC) funded project on honey production. During this first field trip in September 2008, exploratory interviews were undertaken with the various communities with the help of a translator and Nepali sociologist, Mr. Meen Dahal who was working for IUCN at the time. The Masters students from UNIL-IGAR undertook an exploratory geological survey of the landslide areas. All field sites were considered relevant for the study, except for Tamarkam village, which was excluded as it was not considered to be at risk due to landsliding.

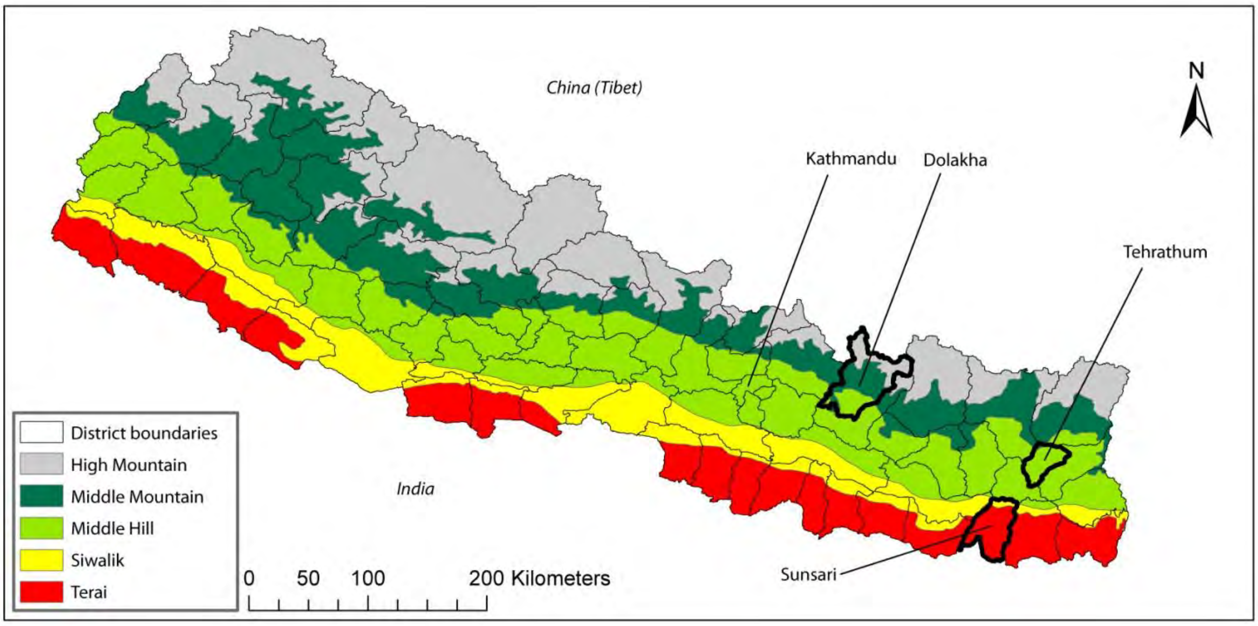


Figure 3. Physiological map of Nepal with all study districts (map by Jaquet, 2011a) , based on data from ICIMOD/MENRIS)

After funding was secured from SNSF in April 2009 for a two-year study, our team returned to the field for 20 days together with Prof. Jaboyedoff in Sepember-October, 2009. By then, we had had time to reflect on what we had observed the year before and be better prepared for another two weeks of intensive fieldwork. For this field trip, we were again accompanied by Mr. Dahal, a Nepali geologist, Mr. Sanjaya Devkota, a second translator, Ms. Inky Rai, a Nepali Master's student in geography at Tribuvan University, Kathmandu and intern Ms. Sophie Paychère (UNIL), who studied and mapped community forests and land use for each of the study sites. Mr. Gopi Krishna Basyal was in parallel conducting his Masters studies (ITC, Netherlands) on flood affected communities in Dharan and Punarbas. We had developed a collaborative methodology for assessing risk and had developed a collaborative household survey questionnaire with Mr. Basyal (Appendix 1).

The study areas are located in Eastern Nepal north of Koshi Tappu Wildlife Reserve, in the Dharan area, Sunsari District at 400-500m altitude just north of the plains, Terai region in a tropical climatic zone; and Basantpur/Sabra village at 2,300-2,500m in Tehrathum District, 90 km north of Dharan in a temperate climatic zone. The field sites are located in the *Churia, (Siwalik* or Middle Hills of Nepal), where tectonic plates are pushing upward along the Main Boundary Thrust of the Himalayan foothills and two major earthquakes took place here, one in 1934 in nearby Bihar, northern India (over 8.0 on the Richter scale) and secondly in 1988 (6.8 on the Richter scale). Here a complex social-ecological system supports marginal settlements and agriculture on steep hillsides, between 40-70° and landslides pose a constant threat to the population. The region is characterized by intensive monsoon rainfall period between June-September with an annual rainfall of approximately 2,000 mm. Average rainfall varies between the Sunsari and

Tehrathum Districts, from 1,800- 2,200 mm per year. The vegetation varies from sub-tropical in the hills region of Sunsari, to temperate in Tehrathum District.

1.8.3. Research in Dolakha District 2008-2009

A third field trip was undertaken in April, 2010 together with Ms. Stephanie Jaquet, Master's student in environmental studies from UNIL-IGAR and senior researcher, Dr. Marc-Henri Derron from UNIL-IGAR. In Kathmandu, this researcher attended a national workshop on disaster prevention and interviewed several actors at the national level dealing with disaster risk reduction. In the meantime, Ms. Jaquet and Dr. Derron, explored a new area in central Nepal, Dolakha district, based on guidance from the Nepal-Swiss Community Forest Project (NSCFP), based in Kathmandu. The reason for this shift, was because Ms. Jaquet's Master's thesis topic was on community forests, forest cover trends, and landslide trends. The selection of study sites was first guided by observations from NSCFP, then based on which communities were facing highest risk.

The fourth field trip was undertaken in October 2010 to Dolakha district, where two communities, Khariswara village (Garimudi VDC) and Thang, thang/Garithok (Suspa VDC) villages were studied in depth, based on Ms. Jaquet's initial field observations, different types of ethnic composition, observed coping strategies and landslide types. For this field trip, we were accompanied by Ms. Sushma Shrestha, (MSc in Geography, Dortmund University), a Nepali geographer who was familiar with the area, having worked for NSCFP and again Mr. Devkota, also familiar with Dolakha District, (Table 1).

The area of study is located north east of Kathmandu in Central Nepal in the Middle Hills and Middle Mountains. Dolakha district has 204'744 inhabitants and 93.5 inhabitants per square kilometer (District of Soil Conservation report, 2006). Geographically, the communities are located on similar north to north-west facing slopes and situated between 950-1500 meters above sea level (m.a.s.l). In Khariswara (950-1350 m.a.s.l) in a temperate climatic zone with average rainfall varying from 1,500-2,000 mm. Most of the rainfall takes place during the monsoon season, June-September (Li and Zeng, 2003). There is a much higher diversity of crops, including a large number of vegetables, productive rice terraces and a variety of fruit trees. This diversity is due to high soil productivity, maintained through terracing, animal and chemical fertilizers, an ancient irrigation system and good knowledge about crops and techniques. Whereas in Thang thang /Gairithok, situated at a slightly higher elevation (1400-1500 m.a.s.l), the main crops are mainly millet, some rice, few vegetables, no fruit trees and low food security is prevalent. Table 1 summarizes the study sites, methods used, outputs, team members and periods visited in chronological order.

Location	Methods used	Outputs	Team members	Period (s) visited
Neelum Valley, Muzzafarabad, Azad and Jammu Kashmir, Pakistan	Geological assessment Risk assessment Exploratory interviews	Case study: Phenomena maps Risk maps Land use history Risk perceptions Coping strategies	K. Sudmeier J. Nessi J. Dubois A. Breguet	2 weeks in October 2006; 2 weeks in April, 2007
Katahare	Geological assessment Risk assessment Exploratory interviews 30 Semi-structured household interview Focus group discussions Participatory risk mapping Transect walks	Case study: Phenomena maps Risk maps Resilience map Land use history Land use & CF maps Demographic & Economic data Risk perceptions Coping strategies	K. Sudmeier J. Dubois A. Breguet M. Dahal K. Sudmeier J. Dubois A. Breguet M. Jaboyedoff S. Paychere S. Devkota M. Dahal I. Rai	3 days in Sept. 2008 4 days in Oct. 2009
Sabra	Geological assessment Risk assessment Exploratory interviews 11 Semi-structured household interviews Transect walks	Case study: Phenomena maps Risk maps Resilience map Land use history Land use & CF maps Demographic & Economic data Risk perceptions Coping strategies	K. Sudmeier J. Dubois A. Breguet M. Dahal K. Sudmeier J. Dubois A. Breguet M. Jaboyedoff S. Paychere S. Devkota M. Dahal	2 days in Sept. 2008 2 days in Oct. 2009
Dharan	Geological assessment Flood risk modelling Risk assessment Exploratory interviews 59 Semi-structured household interviews	Case study: Phenomena maps Risk maps Land use history Land use & CF maps Demographic & Economic data Risk perceptions Coping strategies	K. Sudmeier J. Dubois A. Breguet M. Dahal K. Sudmeier J. Dubois A. Breguet M. Jaboyedoff S. Paychere S. Devkota M. Dahal (G. K. Basyal)	5 days in Sept 2008 5 days in Oct. 2009

Punarbas	Exploratory interviews Focus group discussions 42 Semi-structured household interviews	Case study: Demographic & Economic data Risk perceptions Coping strategies	K. Sudmeier J. Dubois A. Breguet M. Dahal K. Sudmeier J. Dubois A. Breguet M. Jaboyedoff S. Paychere S. Devkota M. Dahal (G. K. Basyal)	3 days in Sept. 2008 2 days in Oct. 2009
Khariswara	Geological assessment Risk assessment Exploratory interviews 13 Semi-structured household interviews Focus group discussions Participatory risk mapping Transect walks	Case study: Phenomena maps Risk maps Resilience map Land use history Demographic & Economic data Risk perceptions Coping strategies	S. Jaquet M-H Derron S. Devkota S. Shrestha K. Sudmeier S. Jaquet M-H Derron S. Devkota S. Shrestha	2 days April 2010 3 days Oct 2010
Thang thang	Geological assessment Risk assessment Exploratory interviews 13 Semi-structured household interviews Focus group discussions Participatory risk mapping Transect walks	Case study: Phenomena maps Risk maps Resilience map Land use history Demographic & Economic data Risk perceptions Coping strategies	S. Jaquet M-H Derron S. Devkota S. Shrestha K. Sudmeier S. Jaquet M-H Derron S. Devkota S. Shrestha	2 days April 2010 3 days Oct 2010

Table 1. Study sites, methods, outcomes, team members, timing in chronological order

Thus, over the period of four years, a total of 100 days were spent in the field, of which 60 were spent in Nepal, representing an iterative approach to research. The next chapter provides a brief outline of the context of landslide worldwide and the Nepal socioeconomic and political context.

Landslides and the Nepal context

2.1 Landslide trends worldwide

The 2011 Global Assessment Report (GAR 11) (UNISDR, 2011) outlines global disaster risk trends: mortality risk associated with major weather-related hazards is declining globally as countries successfully reduce their vulnerabilities through development planning, while strengthening their disaster management capacities. However exposure to all major hazards continues to increase (UNISDR, 2011). GAR 11 also makes a useful distinction between 'extensive disaster risk', or the risk of low severity, high-frequency disasters often associated with highly localized hazards, and 'intensive disaster risk' or the risk of high severity, low-frequency disasters, mainly associated with major hazards. The latter type of risk is the type that we tend to think of first when we think of disasters, as these are the events most reported by the media. Physical hazards is used by GAR 11 to replace the term 'natural hazards' as most hazards are no longer entirely natural. They are commonly aggravated by human activity, or possibly due to climate change weather-related events. Some of the most influential drivers of both types of risk are: badly planned and managed urban development, ecosystem decline and poverty. Climate change related hazards are therefore not considered a major driver of disaster risk but rather an aggravating factor (UNISDR, 2011).

Landslides are a good example of 'extensive disaster risk', low severity, high-frequency and substantially underreported by official statistics or the media as they often take place in remote mountain areas, although there are also examples of very severe urban landslides, such as the mudflows which killed 10,000 people in Vargas, Venezuela (Revet, 2009). According to the 2009 GAR, landslides constitute 13.9% of all disaster deaths worldwide, much less than floods or forest fires (UNISDR, 2009a) (Figure 4). According to our own investigations and other local studies of landslides, the figure is probably underestimated by a magnitude of two, in other words landslides probably count for twice the amount reported.

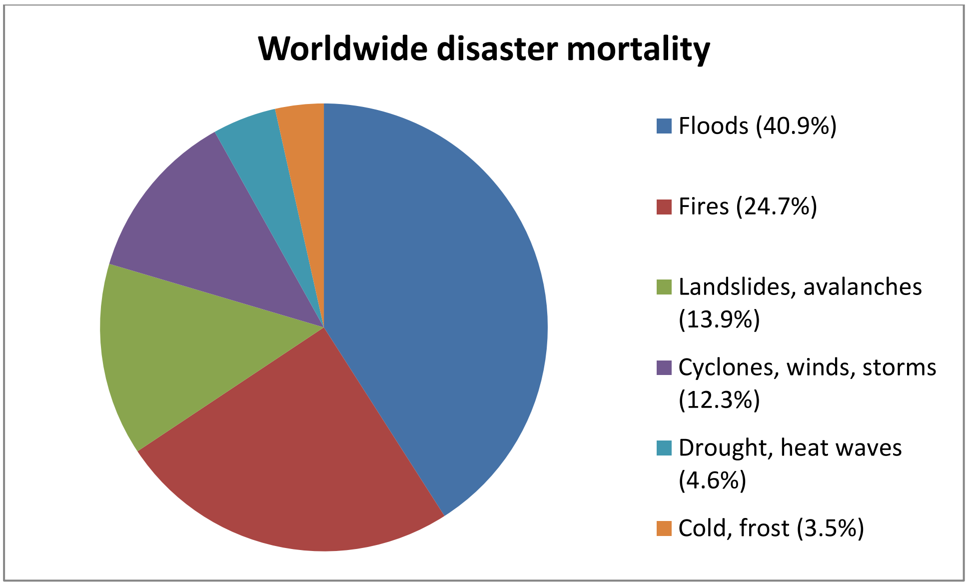


Figure 4. Worldwide disaster mortality by type (modified from UNISDR, 2009a)

Petley (2010) at Durham University, UK, keeps a landslide inventory of all reported landslides worldwide. Figure 5 Illustrates the number of landslides reported by month and year between (2003-2011). 2009 and 2010 have the highest numbers of landslides of years reported. The first half of 2011 seems to be taking a more middle path.

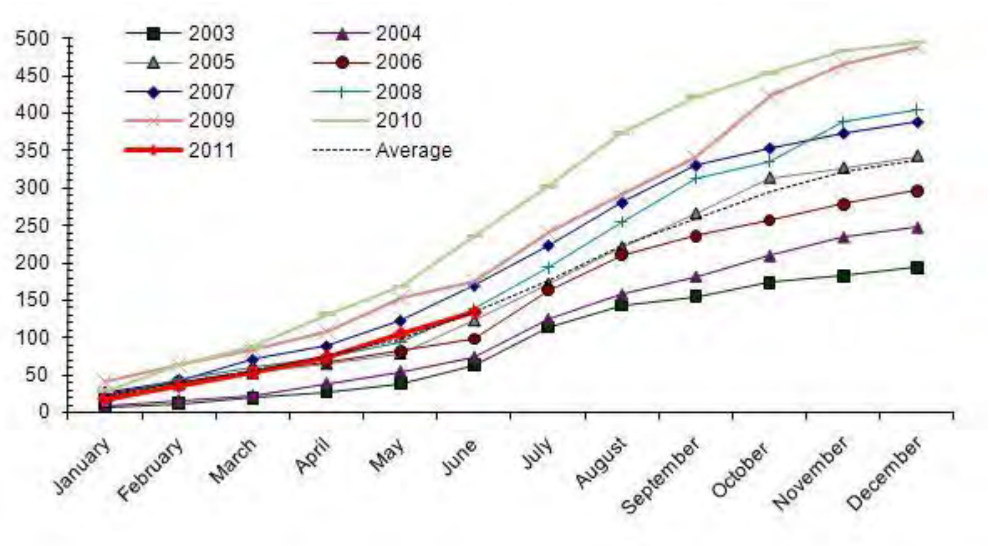


Figure 5. Landslide occurrence worldwide by month and year (2003-2011) (from Petley, 2010)

There are several explanations for this upward trend in landslide occurrence: better reporting, more intensive rainfall patterns and increased human activities such as road building in areas with high landslide susceptibility. Petley (2010) reports that most of the recorded fatal landslides occur in Southeast Asia, and are due to seasonal monsoon patterns. Based upon his study of rainfall data and population growth for this region, he demonstrates that: "although climate change might be expected to increase landslide occurrence, the impacts are minor compared with those of forecast population changes".

2.2 Factors causing landslides

Causes of landslide susceptibility are multiple: weak rock structures (limestone, silt and clays), morphological, tectonic uplift, physical (intense rainfall, earthquake), and human activities (excavation of slope toe for roads, deforestation, irrigation canals (Cruden & Varnes, 1996. ; Sidle, Pearce, & O'Loughlin, 1985). Anthropogenic factors are considered "preparatory factors", whereas rainfall or earthquakes are "triggering factors" (Crozier, 1986; Crozier & Glade, 2004)(Figure 6).

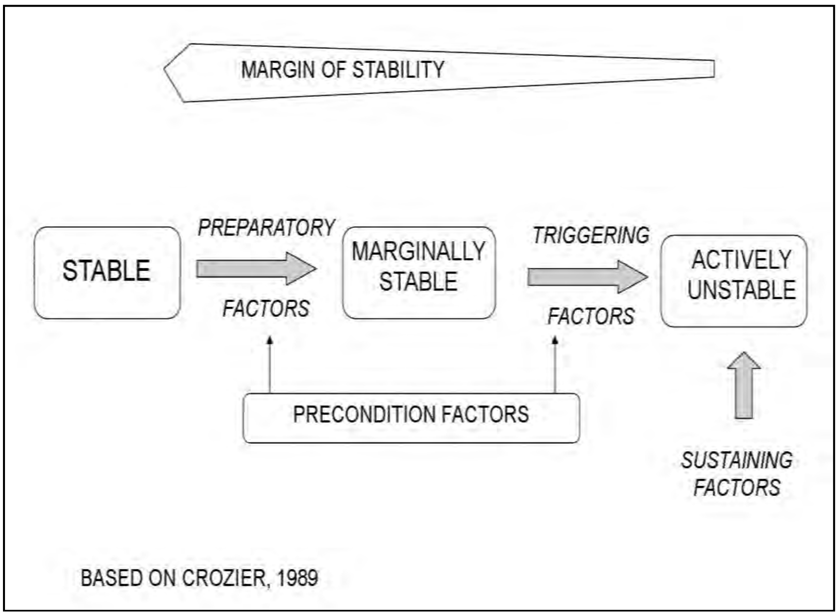


Figure 6. Factors leading to slope instability (modified from Crozier, 1986)

Rainfall can actually be considered both: it contributes to slope instability and it triggers landslides. Disturbance of vegetation cover may be the most important "preparatory factor" leading to shallow landslides, usually defined as less than one meter deep. Shallow landslides are the most common type of landslide with the greatest impact on rural livelihoods in mountain regions.

The role of vegetation for slope stability is of particular importance in the Himalayas as vegetation cover is mentioned as one of the most cost-effective means for reducing landslide risk[1]. Its role is however debated as even slopes with forest cover are subject to landslides either triggered by heavy rainfall or earthquakes. Greenway et al. (1987) explored several characteristics of trees for influencing slope stability (Table 2). Trees can have both a beneficial and adverse influence on slope stability, depending on many localized factors: soil depth, soil cohesion, slope angle, type of trees and hydrological conditions. However, as a general rule it is fair to assume that vegetation cover overall has a beneficial effect on slope stabilization for reducing shallow landslides, gully erosion, slope erosion, whereas this effect usually does not apply to deep seated landslides, which are rather caused by geological conditions (Alcantara-Ayala, Esteban-Chavez, & Parrot, 2002; Crozier & Glade, 2004; Liebault et al., 2005; Phillips & Marden, 2005).

[1] Part of this section was published in Sudmeier-Rieux et al., 2001a

Hydrological mechanisms	Influence
1 Foliage intercepts rainfall	B
2 Roots and stems increase permeability of soil	A
3 Roots extract soil moisture from soil	B
4 Depletion of soil moisture may accentuate soil cracking	A
Mechanical mechanisms	
5 Root reinforce the soil, increasing shear strength	B
6 Tree roots may anchor into firm strata	B
7 Weight of trees surcharges the slopes	A/B
8 Vegetation exposed to wind may destabilize slope	A
9 Roots bind soil particles, reducing susceptibility to erosion	B

A: Adverse to stability
B: Beneficial to stability
Modified from Greenway, 1987

Table 2 . The role of trees stabilizing slopes (modified from Greenway, 1987)

One example where vegetation cover did have a positive influence on shallow landslide occurrence is from northern Pakistan, where our team conducted a study of Neelum River Valley north of Muzaffarabad, situated at the October 2005 earthquake epicenter, magnitude 7.6 on the Richter scale (Peduzzi, 2010; Sudmeier-Rieux et al. 2011a) (Appendix 2)(Figure 7). The thousands of landslides triggered by the earthquake caused thousands of fatalities, destroyed homes, agricultural land and blocked roads for weeks after the earthquake (Owen et al., 2008). Most 90% of the landslides were small (<1,000m^2 in area) and most occurred on the valley's right bank. Results from our study showed that the reason for this higher occurrence of landslides was due to conversion of forest land to grazing areas and rain fed agricultural terraces, whereas the left bank was primarily under state forest protection with a much greater forest cover. Out of 100 earthquake induced landslides studied 18 months after the 2005 earthquake, 86 were on the right bank and 14 on the left bank. Out of 24 rainfall induced landslides occurring in the aftermath of the earthquake, 22 occurred on the right bank. Most of the landslides had occurred on degraded pasture lands or in proximity to rural roads. This example is indicative of the delicate balance and trade-offs between environmental conditions in mountain areas and the needs of human populations, where populations at times push the limits of what mountain ecosystems can support (Jodha, 1995; Smadja, 1997).

Studies of Himalayan conditions conclude that between 50-75% of shallow landslides are caused by human activities, a variation certainly depending on local geological, vegetative and hydrological conditions as well as differing methodologies (Anderson et al., 2011; Barnard et al., 2001; Bathurst et al., 2009; Jaquet et al., in press; Haigh et al., 1995; Lammeranner et al., 2007; Ramsay, 1987). The general implication is that human activities may have enormous consequences for the occurrence of shallow landslides and for rural livelihoods. Regarding the mitigation of shallow landslides, vegetative solutions are likely to be the most cost-effective, especially in a developing country context (Morgan, 2007).

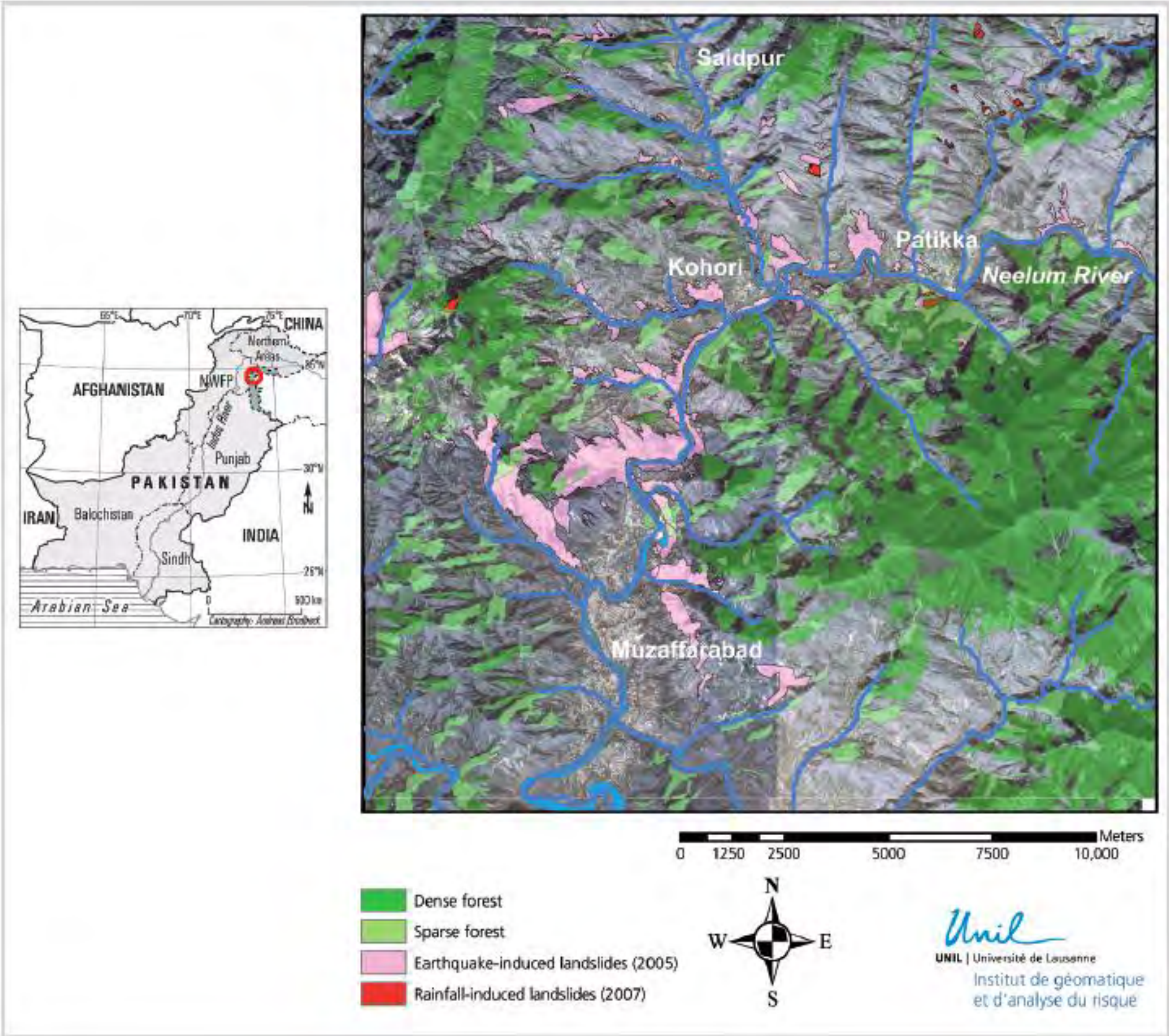


Figure 7. Map of earthquake and rainfall induced landslides and forest cover and Neelum River Valley, northern Pakistan (Map by Dubois/Breguet, 2011, in Sudmeier-Rieux et al. 2011a)

2.3 Disasters and landslides in Nepal:

2.3.1. Geographical context

Nepal is a landlocked country, with only 120 km separating the plains area (Terai) from the high Himalayas. Nepal is commonly divided into five physiographic units that run east to west: the high Himalaya, high mountains, the middle hills region, the Churia or Siwalik range and the Terai region in the plains (Figure 8). Over 80% of Nepal can be considered mountainous or hilly while the remaining 20% lies in the northern Ganga Basin plains, or the Terai. Table 3 depicts the five different physiographic regions, their geology, main soil types, elevation ranges and climate (Agrawala, et al., 2003).

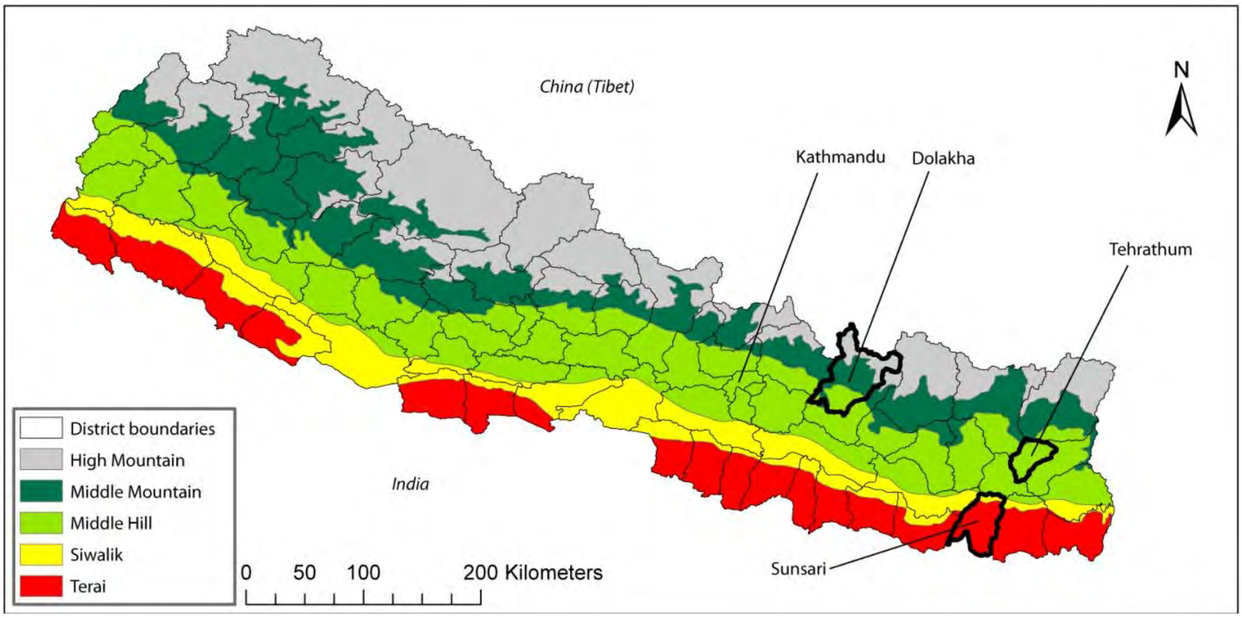


Figure 8. Physiological map of Nepal, with districts where this study took place highlighted (map by Jaquet, 2011a, based on data from ICIMOD/MENRIS)

Region	Geology and soil	Elevation (masl)	Climate	Average Temp.
Terai	Gently sloping, recently deposited alluvium	200	Humid tropical	> 25^{O}C
Siwaliks	Testing mudstone, siltstone, sandstone. Steep slopes and weakly consolidated bedrock. Tends to promote surface erosion despite thick vegetation	200-1500	Moist subtropical	25^{O}C
Middle Mountains	Phyllite, schists, quartzite, granite, limestone. Stony and course textured soil. Conifer forests commonly found associated with quartzite	1000-2500	Temperate	20^{O}C
High Mountains	Phyllite, schists, quartzite. Soil is generally shallow and resistant to weathering	2200-4000	Cool to sub-alpine	10-15^{O}C
High Himalayas	Limestone and shale. Physical weathering predominates, stony soils	> 4000	Alpine to arctic	< 0 to 5^{O}C

Source: CST Nepal 1997

Table 3. Physiological features of main Nepal geographical regions (Agrawala et al., 2003)

The vegetation and climate vary from tropical in the Terai to High Mountains, with annual rainfall varying from 1,000-3,000. A majority, or 80% of this precipitation occurs during the monsoon season, from June to September. Cloud bursts can bring up to 300mm of rainfall in 24 hours and create severe flash flooding (MoHA, 2009).

The bulk of the population in 2008 (83%) was considered rural and 48.7% of the population lived in the Terai (CBS, 2009a). The same year, population density in the Terai was over 301 persons/km2 compared to 157 persons/km2 in the Middle Hills and 32 persons/km2 in the Himalaya, with a continuing population trend of migration from the mountains and hills to the Terai and urban areas.

The geology of Nepal is highly a result of the collision between the Indian tectonic plate against the Eurasian tectonic plate, where strong forces continue to uplift the Eurasian plate along the Main Central Thrust (MCT). The MCT separates the Lower Himalaya from the Upper Himalaya; the Main Boundary Thrust (MBT) separates the Siwalik hills from the lower Himalaya (Zurick & Karan, 1999) (Figure 9).

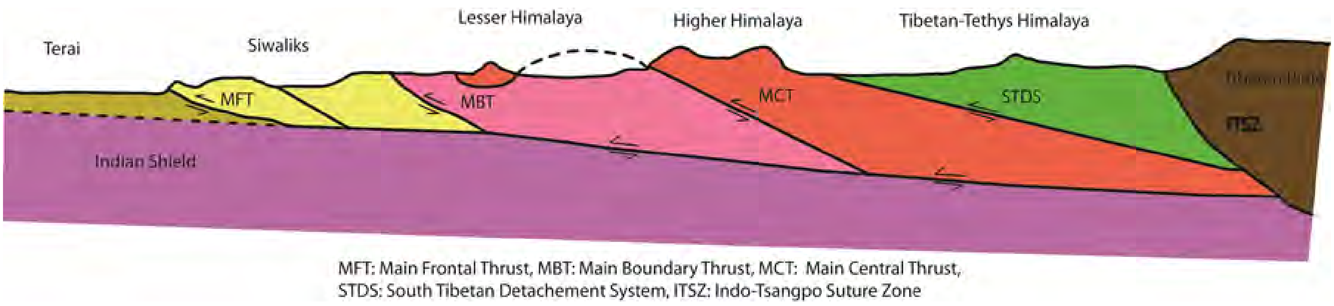


Figure 9. Cross section of Nepal, (Dahal, 2006), (modified by Jaquet, 2011b)

The continuous uplift of the Himalaya gives rise to continuous earthquakes and landslides. The latest destructive earthquake dates from 1988 in eastern Nepal, measuring 6.5 on the Richter scale when about 100 people were killed. An earthquake in 1933 measuring 7.3 on the Richter scale affected Kathmandu, killing 8,519 people and destroying 250,000 homes. Both of these earthquakes triggered a number of landslides and left cracks and instabilities, which continue to create landslides during heavy rainfall or other land disturbance. The second most devastating disaster in Nepal's recent history was caused by a monsoonal cloudburst in 1993, triggering more than 2,000 landslides, causing mudflows and flooding. Half a million people were affected and 1,170 people were killed (MoHA, 2009). As the pre-Himalayan ranges are the first mountain barriers for the monsoon clouds moving north from the Bay of Bengal, rainfall events here of 500mm in 24 hours are not uncommon. Landslides are thus a common and natural phenomenon in the Nepal landscape, flattening out steep terrain and creating alluvial fans which the population has transformed over the centuries into productive terraces. The Churia or Siwalik hills are

Climate Change Predictions for Nepal

- Average annual temperature increased by 0.01°C in the foothills, 0.02°C in the middle mountains, and 0.04°C in the higher Himalayas , or 1.4 °C increase for the country predicted by the 2030s;
- Night-time temperatures increased across most of the Eastern Himalayas in Spring and Summer;
- Less monsoonal rain across the high mountains and more monsoonal rain along the southern hills;
- Rapid decrease of snow cover and glacier retreat;
- Excess water flows in wet season, lower flow in dry season.

(Tse-Ring et al., 2010; WECS, 2011)

especially prone to landslides as most are older debris fans, which rise steeply from the Terai plains. The Siwalik rocks are a series of sand stone, pebble beds, shales, course conglomerates and thin limestone which are porous and easily eroded as a result of high rainfall events (Upreti & Dhital, 1996).

2.3.2. Disaster context

Because of its topography, exposed population and weak governance, Nepal is considered a hotspot for disasters. It was listed 13th in the German Watch Global Climate Risk Index based on the extent to which a country is affected by weather-related disasters (Harmeling, 2010) (Table 4). On average, 127,454 persons were affected every year during the period 1971-2009. In 2009, a relatively average year for hazard events, economic losses due to flooding and landslides were estimated at $US 480,000 (DWIDP, 2009) and 900 people died due to physical hazards (MoHA, 2009). In the high mountains to middle hills, flash floods and landslides occur frequently, sweeping away entire villages and terraced land. In the low lying areas, monsoon-related flooding can be an annual occurrence, in addition to frequent fires in clustered thatched villages.

Event	Deaths	People affected	Loss of land (ha)	Reported direct loss (Million NPR)
Drought	-	41	8900	0.27
Earthquake	23	122	-	196
Epidemic	420	1020	-	-
Fire	30	20	9.5	169
Flood	77	89,615	5323	100
Forest fire	0.68	289	85.7	28
Landslide	**105**	**12,974**	589	23
Other	64	9749	7846	55
Total	720	127,454	**22,755**	**375**

Table 4. Disaster losses in Nepal annual average 1971-2009, from (MoHA, 2009)

However, the official statistics do not sufficiently reflect the number of persons affected by smaller flash floods and shallow landslides, which are diffuse, destroy livelihoods but do not make the headlines. Landslides have an underestimated impact on rural livelihoods and food security in Nepal, with little attention received from government, the international community, or researchers (Sudmeier-Rieux et al., In press (a)).

Figure 10 shows data linking landslide deaths, number of landslides and an monthly precipitation for the period 1980 to 2010 inclusive, from the Durham University Landslide database (Petley, 2011). The grey line shows the average monthly precipitation for Central Nepal for the period June-August for each year. The data emanate from the Global Precipitation Climatology Centre (GPCC data, 1986 to 2010, Petley, 2011); the solid black line shows the number of recorded deaths due to landslides in Nepal for each year for the period 1980 to 2010; the dashed line shows the number of recorded landslides that caused one or more deaths. What is interesting about this graph is the rising trend with time for all three data sets in spite of considerable inter-annual variability. The worst spike for all three occurred in 2002, although the last few years have produced high numbers of landslides fatalities. Average monthly summer precipitation (rainfall) also seems to be increasing in central Nepal. Almost all the annual rainfall in Central Nepal falls in the summer monsoon, which runs June to September in Nepal. There are thus obvious correlations between the average monthly summer rainfall and the number of landslides that occur.

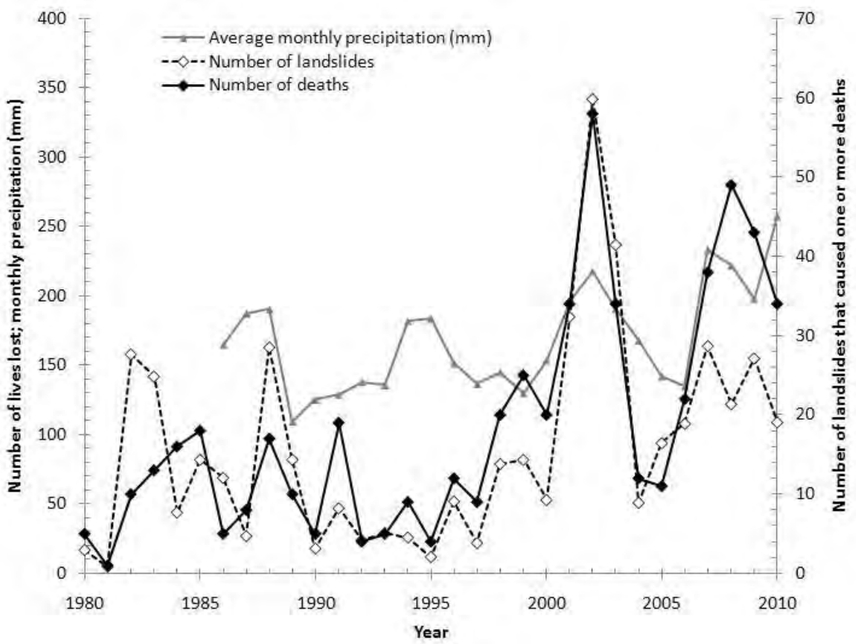


Figure 10. Landslide data for Nepal, 1980-2010 (Petley, 2011)

Figure 11 captures this point with a regression analysis between number of fatal landslides and average monthly precipitation for Nepal 1986 to 2010, split into two periods 1986 to 1999, when the data are less robust as the database was constructed retrospectively, and 2000 to 2010 when the data are better (Petley, 2011). According to Petley (2011), "although there is considerable scatter, it is clear that years with more intense rainfall are associated with more landslides".

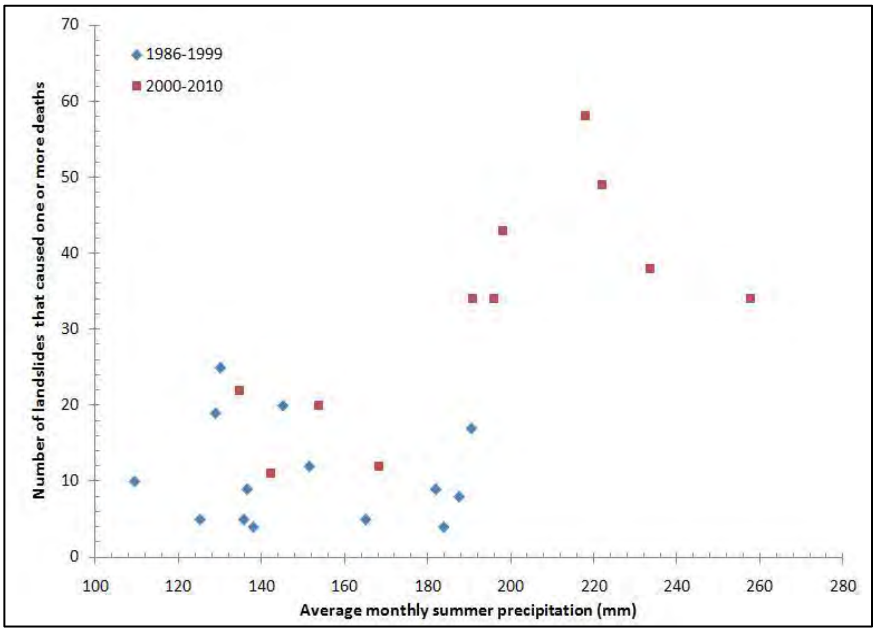


Figure 11 . Correlation between number of landslides and average monthly precipitation, Nepal 1986- 2010 (from Petley 2011)

Figure 12 shows the number of fatal landslides in Nepal since 1978, with a significant spike in the early 2000s, causing 2,179 deaths (Petley et al., 2007). The areas most affected by landslides are the heavily populated *Siwaliks* and Middle Mountains. According to the authors, the principal trigger for these landslides is monsoon rains. Out of 397 landslides during this period, none occurred between November and April (Figure 13). The authors argue that two human factors have led to the increase in the number of landslides: deforestation and the expansion of the road network in Nepal. Forest cover continues to decline nationwide by 1.35% annually, and is most likely to affect shallow landsliding, surface and gully erosion (Petley et al., 2007). Since 1990, the road network has rapidly expanded but without taking the necessary engineering measures for stabilizing adjacent slopes. New roads have also given people incentives to settle near roadsides, often with increased landslide risk (Oven, Petley, Rigg, Dunn, & Rosser, 2008).

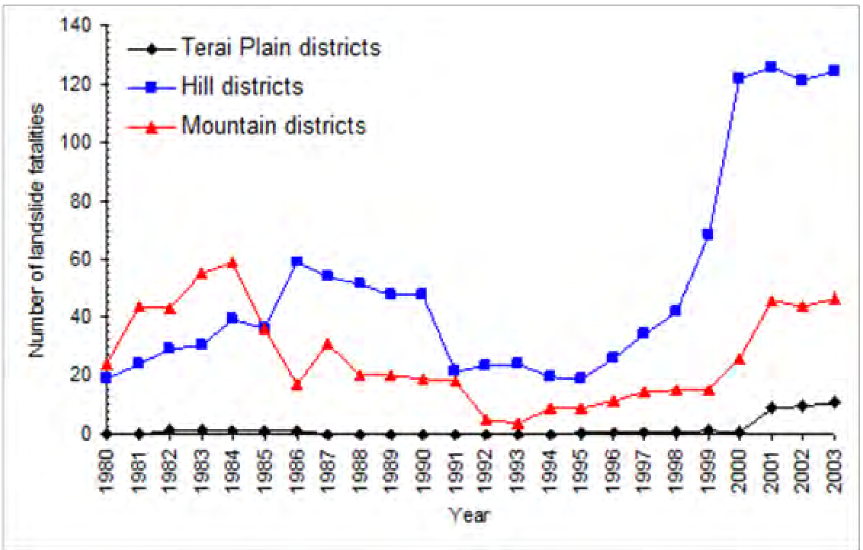


Figure 12. Landslide trends by region 1980-2003 (from Petley, 2007)

Figure 13 illustrates this correlation between rainfall and landslide occurrence, with an obvious spike occurring during monsoon months, July August September. Models of climate change are uncertain at best, however data on monsoon rains point toward more intense rainfall patterns. Data analyzed by Petley (2009) show the South Asian Seasonal Monsoon Index (SASMI) correlated with a higher incidence of landslides since 1995. This trend was confirmed in our discussions with the local population, of which a majority stated that the monsoon period was becoming shorter, hotter but more intense. Petley et al. (2007) findings correlate with DesInventar data showing a similar trend in landslide occurrence (Figure 13).

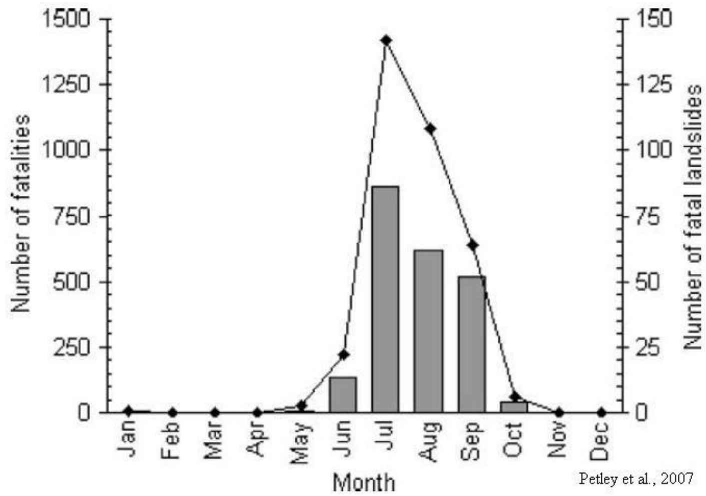


Figure 13. Landslide occurrence by month in Nepal (from Petley et al. 2007)

DesInventar data show the distribution of landslide occurrence across Nepal from 1971-2007, with the highest occurrence in those districts of the Siwalik and Middle Hills areas, especially in the Eastern and Central regions (DesInventar, 2011)(Figure 14, Figure 15).

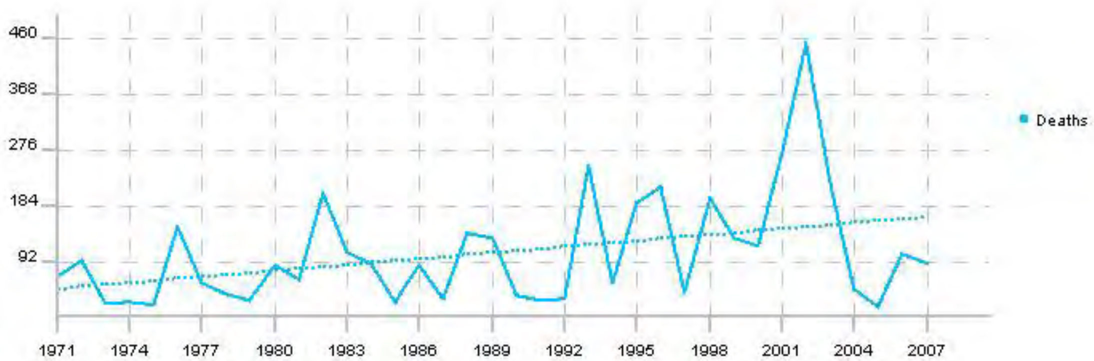


Figure 14. Nepal landslide occurrence, 1971-2007 (from DesInventar, 2011).

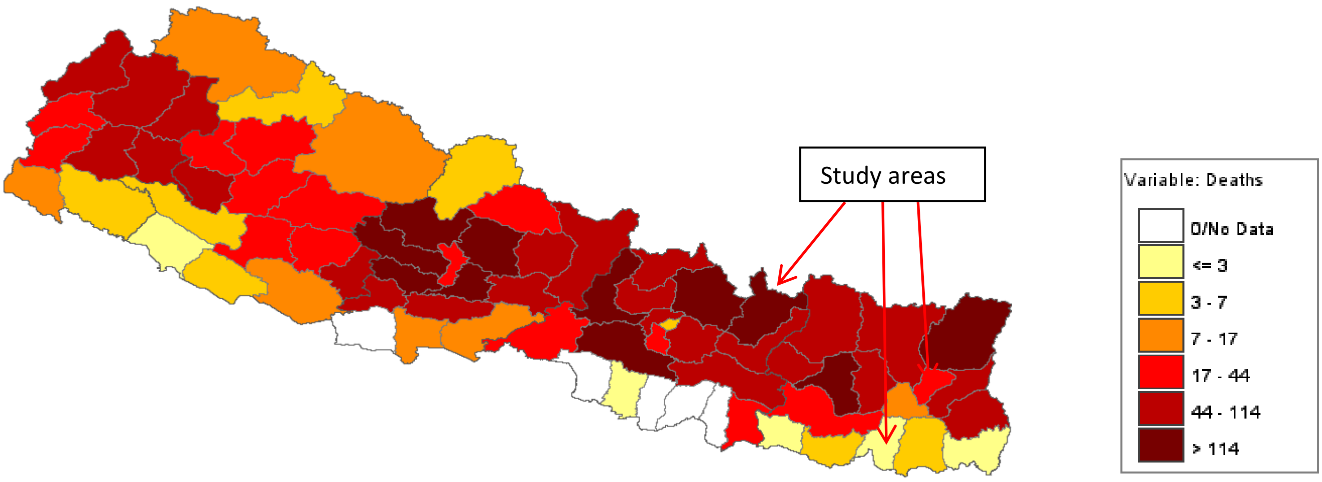


Figure 15. Fatal landslide occurrence in Nepal by district 1971-2007 (from DesInventar, 2011).

Although the DesInventar database contains the most accurate disaster statistics, a detailed study of disasters in Dolakha district showed that these figures are gross underestimations of actual numbers as DesInventar data are based on reported events to the media and government authorities. Especially for landslides, which commonly carry away agricultural land and houses, or cause fatalities in remote areas, the statistics are underestimated by as much as 200% (Jaquet, 2011a). Figure 16 shows total casualties by landslides per district in Nepal as developed by Komal and Gadema (2008) based on historical records of landslides between 1900-2007 as reported in newspaper articles and government documents. The data are quite similar to that reported by DesInventar database, especially for the Central and Eastern districts, we note that in both cases, Dolakha district is a hotspot for landslides, Terathum district is a mid-level district and Sunsari, a low-level district due to the largely Terai landscapes of this district.

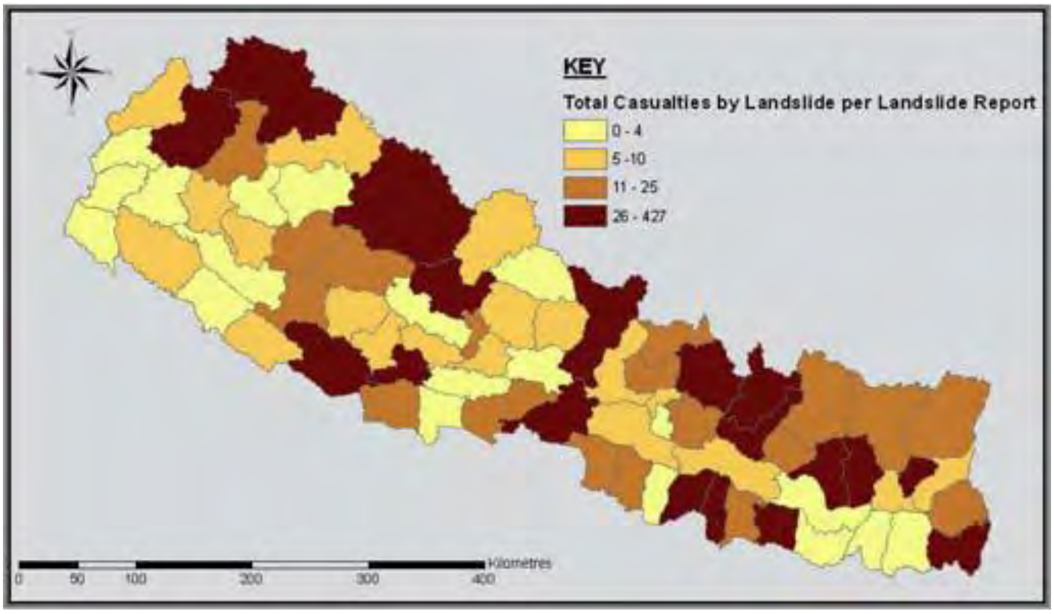


Figure 16. Total casualties by landslides per district in Nepal (1900-2007) (Komal & Gadema, 2008).

In spite of the data uncertainties, it is clear that landslides pose a problem to populations in many districts of the Siwalik and Middle Mountains. Low statistics on landslide occurrence together with the dispersed nature of landslides have led to low awareness about the landslide problem in Nepal, which is widely believed to be mainly due to natural causes with few possibilities for mitigation and low impact on the population compared to flooding. Most of these commonly held beliefs are false but have led to a lack of government policies, practices and action related to landslide mitigation in Nepal.

2.3.3. Land use trends

Part of the false belief that most landslides are natural and little can be done to reduced landslide risk can be attributed to the literature on land degradation and landslides in Nepal, which is divided on the role of human versus natural causes. Landslides have been considered a largely natural phenomenon in Nepal, largely influenced by the alarmist theory of the "Himalayan Tragedy" which blamed flooding in the Ganges plains on deforestation in the Himalayas mainly due to farmer activities (Eckholm, 1975). This debate was followed by a rebuttal of Eckholm's theory, instead insisting on the natural character of erosion, landslides and flooding in the Himalayas (Ives, 1987; Ives & Messerli, 1989; Thompson & Warburton, 1985). Other geographers rightly posit that the truth lies somewhere in between (Blaikie, 1988; Paudel & Thapa, 2004; Smadja, 1997; Zurick and Karan, 1999). The Laban (1979) study, "Landslides in Nepal" has been particularly influential to this debate and is still largely considered the most comprehensive study of landslides in Nepal. It concludes that of the 130 landslides surveyed by airplane in 1979, 26% were considered due to human activities and 5% due to roads or trails (Laban, 1979). This figure, 26% now over 40 years old, has remained unchallenged and is still the yardstick for many recent publications explaining the causes of landslides in Nepal. However a more careful reading of Laban (1979) actually points to relatively high numbers of human induced landslides, considering the very low density of the road network four decades ago. Interestingly, the study cautions: "the high impact of road construction on landslide occurrence can be expected to increase dramatically, particularly if road construction continues under present engineering practices" (Laban, 1979).

There is therefore increasing evidence that shallow landslides are shifting from mainly highly degraded areas along waterways and gully erosion, largely caused by grazing, toward landslides along roads (Jaquet, 2011b). The hypothesis is that Community Forests, established by the Forest Act in 1993, has had a large influence on increasing forest cover in selected areas, due to improved grazing practices and sustainable forestry with a positive influence on the occurrence of shallow landslides. Jaquet (2011b) studied forest cover changes 1979-2009 in Dolakha district, which was one of the first in Nepal to receive significant NGO (mainly Swiss) assistance for organizing and training Community Forest User Groups (CFUG) (Figure 17). The study shows the general increase of forest cover from 20% cover in 1992 to 46% cover in 2009. Forest cover has especially increased in gullies, formerly degraded areas, expanded forest areas and next to rivers (Jaquet, 2011b). This change is mainly the result of improved forest management practices, grazing management, better control on illegal harvesting and incentives for forest plantations (Gautam, Webb, & Eiumnoh, 2002; Pokharel, Stadtmüller, & Pfund, 2005).

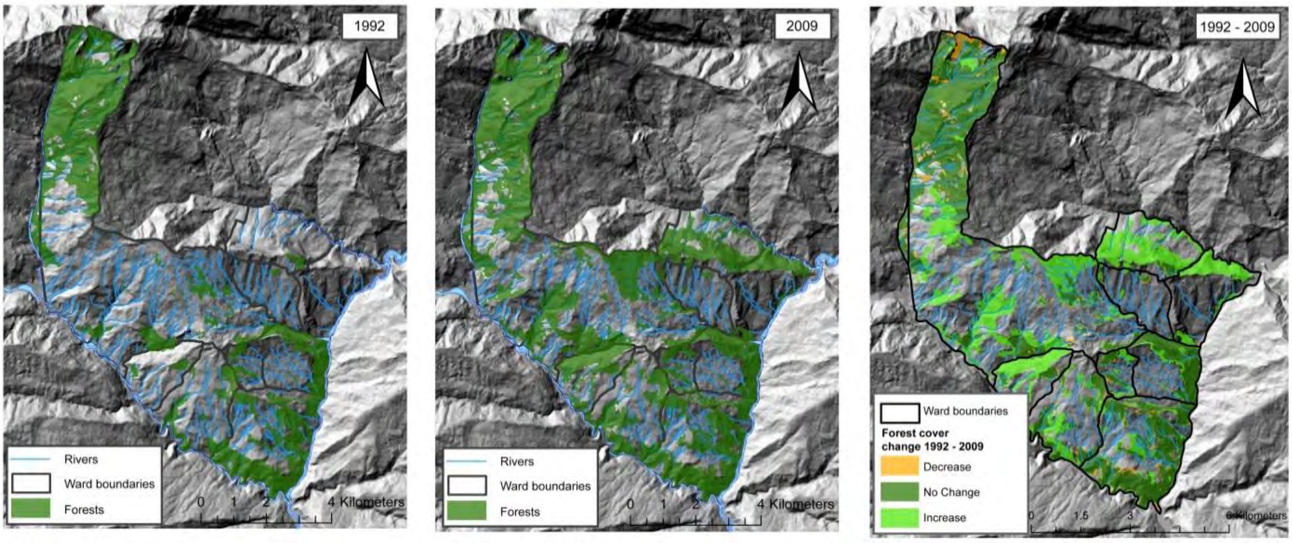


Figure 17. Forest cover changes Bimeshwar municipality delineated from aerial photographs 1979/1992 Department of Survey, Kathmandu and Google Earth image (2009) (from Jaquet, 2011b)

Although the forest cover for all of Nepal has decreased by 3.4% since the 1970s (Table 5) and is still decreasing by 1.35% annually, it is decreasing at a slower rate than in previous years (Petley et al., 2007). Most forest decline is occurring in the Terai, due to a continued influx of population and pressure on the greenbelt which provides a buffer between the Terai and the Middle Hills area (Jodha, 1995). Table 5 also shows a very large increase in shrub land (40.4%) and bare land (6.0%) with a large decrease in snow cover (-24.6%) and grassland (-8.2%) between 1970s and 2000s. These changes in land cover are most likely due to the warmer temperatures and population increases noted in the Himalayas over the past decades (Tse-ring, Sharma, Chettri, & Shrestha, 2010).

Broad land cover types	1970s	2000s	Change %
Forest	273,426	264,117	-3.4
Shrubland	43,050	60,443	40.4
Cultivated land	112,631	113,233	0.5
Grassland	39,902	36,639	-8.2
Bare land	22,589	23,953	6.0
Water bodies	4,119	4,108	-0.2
Snow cover	27,514	20,741	-24.6

Table 5. Land use cover changes in the Eastern Himalayas 1970s-2000s, sq.kms from (Tse-Ring et al. 2010)

Table 6 shows the land-use pattern and spatial extent by development region, ecological zone and residence of Nepal (2001). We note that the greatest forest and shrub area is in the Hills ecological zone and the Mid-Western development region.

Area	Approximate Elevation (in masl)	Area (sq km)	Area (%)	Forest Area (sq. km)	Shrub Area (sq. km)	Forest and Shrub Area (%)	Pop^n. Density
Development Region							
Eastern		28450	19.33	7361	3626	38.62	188
Central		27405	18.62	9186	2538	42.78	293
Western		29407	19.98	7424	2669	34.32	155
Mid Western		42373	28.79	11924	3942	37.44	71
Far Western		19546	13.28	6874	2739	49.18	112
Ecological Zone							
Mountains	Above than 4870	51817	35.21	2281	1678	7.64	33
Hills	600 - 4870	61345	41.68	26544	13722	65.64	167
Tarai	Below than 600	34019	23.11	13945	114	41.33	330
Residence							
Rural		143905	97.8				135.97
Urban (Municipality)		3276	2.2				985.23
Total		**147181**	**100**	**42682**	**15514**	**39.60**	**157**

Source: Central Bureau of Statistics (Population Census- 2001) and Department of Forest Research and Survey, 1999.

Table 6. Land-use pattern and spatial extent by development region, ecological zone and residence. 2001. (CBS, 2008)

Table 7 illustrates land use cover (2001) in more detail for those districts in Nepal where our six study sites are located. The average forest cover for all 75 districts is 74,663 km^2. Thus, Dolakha district is somewhat above average for forest cover.

District	**Total Forest Area**	**Shrub**	**Agricultural land/ grass**	**Water bodies**	**Barren land**	**Snow**	**Other**	**Total (km2)**
Dolakha	781.1	411.9	547.8	4.0	160.3	229.1	29.8	2,164.1
Sunsari	213.0	15.1	917.9	62.6	68.6	0	0	1,277.3
Terhathum	200.3	124.99	349.2	1.3	4.9	0	0	680.6
Nepal Total	55,999.8 (37.9%)	12,832.3 (8.7%)	40,616.3 (27.5%)	646.6 (0.4%)	16,834.9 (11.4%)	19,740.0 (13.3%)	1,083.8 (0.7%)	147,751.6 (100%)

Table 7. Land-use cover 2001 for selected districts of Nepal, sq. kms. (modified from CBS, 2008)

On agricultural land, most studies agree that the most common larger (>10 m^3) and damaging landslides in agricultural lands occur primarily on rain-fed terraces *(bari),* followed by those occurring on irrigated *(khet)* terraces, abandoned fields and old landslide areas (Caine & Mool, 1982; Fort, Cossart, & Arnaud-Fassetta, 2010; Gerrard, 1994; Smadja, 1997). *Khet* landslides are likely the most frequent but small in nature (>2m^3) (Gerrard and Gartner, 2002) and due to water mismanagement. Small landslides that can be repaired cost significant time and labor for farmers, estimated at 14 days on average for repairing *khet* failures (Gerrard and Gartner, 2002), in addition to lost yields. Landslides are therefore extremely costly to households in rural areas, already strained to meet food security requirements. As the focus on land use changes in Nepal shifts to understanding climate change impacts, more recent large-scale inventories of landslides are required to cross validate whether the causes are predominantly natural or human so that this information can be used to influence policymaking for landslide risk reduction.

2.4 Socio-economic and political context of landslide management in Nepal

A few pages to describe the socioeconomic context of Nepal will obviously not suffice to paint a complete picture of the complexity of Nepal society. From a largely nomadic society at the crossroads between China and India, to the influence of Hinduism and Buddhism, the establishment of a monarchy and the recent political upheaval and rise of a Maoist led government, Nepal is very dynamic society. It is today strongly influenced by internal political upheaval, resulting in an extremely volatile political situation, and by external forces: globalization, market fluctuations and demand for cheap foreign labor drawn by the Gulf States' construction boom. The following sections will attempt to highlight some of the key issues and information required to better understand the Nepal socio-economic and political context in which landslide risk management resides.

2.4.1 State of the economy

Nepal, with a population of 23 million, is also one of the world's poorest countries, with 38% of its population surviving on US$1 per day (Agrawala et al., 2003). According to new data, the country has however made recent strides in poverty alleviation, an astonishing drop by 18 points from 31% under the poverty limit to 13% under the poverty limit, largely due to the high amounts of remittances, now received by 55.8% of all households (Khanal, 2011; CBS, 2011). As this thesis was being finalized, a number of academics and journalists were questioning the validity of these statistics provided from the Nepal Living Standards Survey III released in August, 2011. It was conducted by the Central Bureau of Statistics between January 2010 and 2011 with technical support from the World Bank but final statistics have not yet been released. If valid, the survey also notes a reduction in income inequality for the first time in 6 years (Adhikari, 2011). The proportion of the population living in rural areas remains high, 83% in 2008, a decline from 91% in 1990, with a total population of 23.1 million (CBS, 2009a). The most poverty affected region is the Middle and High Mountains with 56% of residents living in poverty and the mid- and western regions, where local food production sometimes only covers 3 months of the annual household requirements (Government of Nepal et al., 2008). Nepal relies heavily on agriculture (40% of its GDP) providing income to 81% of the labor force (Agrawala et al., 2003). It is heavily dependent on natural resources for most of its income generating activities: food production and tourism revenues, making Nepal very sensitive to climate variability (Agrawala et al., 2003).

Although it has made major improvements in education, is Nepal is ranked 138th out of 169 countries in the UNDP 2009 Human Development Index (UNDP, 2009). Most economic and development indicators point to low development, whether infant mortality rates, literacy rates (Table 8) or access to basic sanitation and drinking water (Government of Nepal, 2007; WECS, 2011). In 2010, only 72% of the country's population had access to basic water supply and 25% of the whole population had a sanitation facility (WECS, 2011). Table 7 is interesting as it shows Nepal Government growth projections for the next three years, established in 2007 before the 2008 elections, which overthrew the government and monarchy.

Table A: Quantitative Targets

S.No.	Indicators	Situation as of FY 2006/07	Interim Plan Target
1	Economic growth rate (%)	2.5+	5.5
	Agriculture	0.7+	3.6
	Non-agriculture	3.6+	6.5
2	Population below poverty line (%)	31	24
3	Employment growth rate	3.0	3.5
4	Human Development Index (HDI)	0.534	0.570
5	Gender Development Index (GDI)	0.520	0.556
6	Gender Empowerment Measurement (GEM)	0.351	0.450
7	Women receiving delivery assistance from health workers (%)	23.4	35
8	Contraceptive prevalence rate (%)	48	51
9	Total fertility rate (women aged 15-49 years)	3.1	3.0
10	Maternal mortality ratio (per 100,000 live births)	281	250
11	Infant mortality rate (per 1,000 live births)	34	30
12	Child mortality rate (per 1,000 live births)	48	42
13	Women's representation in overall state machinery (%)	-	33
14	Population with access to improved drinking water (%)	77	85
15	Population with sanitation service (%)	46	60
16	Literacy rate (%) - 6+ years	63	76
17	Literacy rate (%) - above 15 years	52	60
18	Net enrollment rate at the primary level (%)	87.4	96
19	District Headquarters with road connectivity (number)	63	75*
20	Telephone, including mobile (per 100 density)	6.5	25
21	Electricity generation (MW)	560	704
22	Irrigation (Hectares)	1,168,144	1,263,824

+ Situation in FY 2006/07
* Simikot, district headquarters of Humla will be connected from Tibet side

Table 8. Economic and demographic indicators 2006/2007, and targets for the interim plan 2008-2010. (Government of Nepal, 2007)

2.4.2. Nepal: a history shaped by several cross roads

We note how Nepal's geographical position, at the crossroads between two great civilizations to the North and South has framed its development through history (Ramirez, 1997). As a result, Nepal's current land use patterns, approaches to disaster risk management and current development patterns are anchored in historical developments that have shaped the current administrative structure, and how people manage and relate to natural resources (Blaikie, 2000a; Blaikie, Cameron, & Seddon, 2000b; Jodha, 1995). These historical developments can roughly be divided into four different periods: the pre-Gorkhali period (before 1769); the Gorkhali period (1769-1846); the Rana period (1846-1950); 1950 – present. Oven (2011) has compiled a useful summary (Table 9) of the physical/environmental; demographic; economic and political characteristics that have created Nepal of today.

	Physical/environmental characteristics	*Demographic characteristics*	*Economic characteristics*	*Political characteristics*
Before 1769 (pre-Gorkhali period)	First settlers practiced shifting cultivation Farming practices based largely on transhumance/ pastoralism Gradual shift towards sedentary agriculture Introduction of irrigated rice cultivation in the valley bottom Limited environmental stress; low population densities; abundant land	First settlers were the Kiratis (c.900 AD) Arrival of the Tamang and Sherpa ~400 years ago Arrival of the high caste Hindu immigrants including the Brahmins and Chetris ~300 years ago Arrival of the Newars ~400 years ago. Early population growth linked to an increase in agricultural production.	Tribal areas: subsistence farm economy based on transhumance; barter trade with Tibet Hindu dominated areas: land and labour viewed as the dominant resource. Clearance of forest land for agriculture Trans-Himalayan trade	Approximately 60 autonomous petty hill states (Hindu dominated) Egalitarian clan based tribal land Newar rulers in the Kathmandu Valley subjugated the trade routes (c.1600-1700s) The Gorkhalis subjugated Sindhupalchok and the trade routes (c.1745)
1769-1846 (Gorkhali Period)	Hills - opening up of forest land for agriculture Advanced state of deforestation reached by the late 1700s Maximised the limited carrying capacity of the land Reclamation of agricultural land in the Terai	Population growth Gradual encroachment of indigenous tribal lands Official policies encouraging immigration into Nepal from Tibet and India to encourage land reclamation and settlement	Economy in the hills was still dominated by subsistence agriculture and barter trade Initial increase in agricultural productivity in the hills Agricultural expansion in the Terai and the export of crops to India	Expansion of Gorkha control and the unification of the 'petty states' State intervention focused on agricultural expansion Revenue generation through land taxation increased c.1830s
1769-1846 (Gorkhali Period) Continued		Increase in sedentary agriculture linked to the introduction of maize Land allocated to officials and servants of the state leaving limited land for the peasants to cultivate Enhanced land tax resulted in outmigration from the hills to India (c.1830)	Establishment of the timber trade in the Terai	Land grants made in increasing numbers Little emphasis placed on improving productivity or sustainable resource management 1814 -1816 British-Nepal War - Nepal became a political dependency or 'semi-colony' of the British Nepal remained largely autonomous with British control extending to foreign and trade policies only
1846-1950 (Rana Period)	Local responsibility for forest management emerged in the hills independent of government policy Deforestation in the hills ceased as the remaining resources were necessary for the hill farming system The exploitation of forest gained momentum in the Terai	Continued population growth Food shortages in the hills Unequal access to land Pressure on land and the absence of employment opportunities resulted in outmigration from the hills to the Terai, Bengal, Assam, Burma, Darjeeling and elsewhere By 1930 one Nepalese-born person in twenty was living in India Introduction of welfare measures	Focus remained on the physical expansion of subsistence farming Impoverishment of the peasant majority Increased revenue from timber sales and the annual value of trade increased six fold by 1900 No industrial development or investment in the manufacturing sector Economic stagnation	Emergence of the Rana Dynasty and a regime of 'Hinduisation' Evidence of state corruption (25-50% of state revenue went directly to the Ranas) Minimal state intervention Focus on agricultural expansion mainly in the Terai Tax exceptions on any newly-reclaimed land continued (3 years exemption in the hills and 5 years in the Terai to promote

1846-1950 (Rana Period) Continued			Trade deficit	immigration) 1923 Nepal became independent from the British
1950-present	Continued forest exploitation in the Terai for agriculture and timber Limited environmental change in the hills Links made between deforestation, agricultural expansion and an assumed acceleration in soil erosion and landsliding in the Middle mountains have been challenged	Despite population growth the mountain and hill areas remain sparsely populated Limited land reform Outmigration continued Population pressure in the Terai resulting in a reduction in the size of land holdings Focus on welfare issues and education	Nepal remains an agrarian economy with a focus on subsistence production Households increasingly dependent on off-farm income Failure of the state to stimulate economic growth Failure of agricultural development No notable industrial development Closure of the Nepal-China border in 1959 - decline in trans-Himalayan trade Trade agreements with India which undermined and replaced local production and flooded the market with Indian commodities	Fall of Rana family Series of weak ministries 1962 introduction of the party-less panchayat political system "grassroots development" State initiation of: • Economic planning • Land reform • Road provision Attempts at land reform (1960s), natural resource management etc. Rise in political consciousness - emergence of the people's movement 1990s - end of the Panchayat political system and the restoration of multi-party democracy 1996 – People's War

Table 9. Economic, demographic and political processes giving rise to present day Nepal from (Oven, 2011).

2.4.3. Ethnicity, caste and communities in Nepal

From Table 9, of noted interest for this study, is the Hinduisation of Nepal society, i.e., the establishment of a stratified caste system. Although the caste system was officially abolished in 1962, its legacy continues to mark Nepal society. It was imposed by so-called 'high caste groups' *Brahmins* and *Chhetris*, emigrating north from India, first to the middle Hills area , later to the Terai, yet with a fair amount of resistance by many of the indigenous groups such as the *Rai, Sunwar, Limbu* (Gaboriaux, 1995). What resulted is a melting pot of both Hindu, Buddhist and local 'animist' beliefs and traditions, at times co-existing, giving rise to a caste-system very different from that found India (Bista, 2004). For example, non-Hindu indigenous groups practicing their own local religion, may call upon a *Brahmin* priest to perform a wedding ceremony or for a purification ceremony after a funeral (Gaboriaux, 1995). This group , together with the *Chhetri* Ranas and a few high caste Hindu *Newars* have traditionally filled most of the important positions of the royal family , administration and military.

The government of Nepal officially recognizes and categorizes three different groups of castes and ethnic groups (NFDIN, 2001):

- 'High-caste': the uppermost social status within Nepal is reserved for the *Brahmins* and *Chhetri*. Traditionally constituting the priestly caste and for bid in the culture from the consumption of alcohol and with a range of dietary restrictions.
- *Janjati:* this is not technically caste group of such, rather a number of indigenous ethnic groups: e.g. *Rai, Tamang, Gurung, Limbu.* Although not governed by the same norms and behaviors associated with the caste system, the *Janjatis* fall under the 'unslaveable' label;

- 'Low-caste' groups: *Dalits* previously referred to as *'untouchables'* constitute the lowest social order and are still victim to discrimination, in spite of efforts to change this marginalization (Pradhan & Shrestha, 2005).

This classification is complex as some of the indigenous ethnic groups can also be considered marginalized, while others, mainly some indigenous Newars and Shresthas are actually privileged. The classification is used to ensure quotas for representatives of the Constituent Assembly (CA) and in government efforts to reduce discrimination. Another classification is the 'occupational castes', which cross cuts the above three categories and places groups into traditional occupations, such as blacksmiths, goldsmiths, miners., although with greater population mobility these categories are becoming less important.

Bista (2004) emphasizes the role played by ethnicity in shaping how Nepalis relate to each other, their prospects for employment, their relations to authorities and their abilities to manage various types of risk. Although the role of hierarchy, ethnicity and fatalism are changing, especially during the decade of the Maoist uprising, it still profoundly has an influence on Nepal society (Wagle, 2010). The practice of *Chakari* exemplifies the notion of hierarchy. Originating in religious ritual practices of obeisance, it extends to people of the governing classes and people in certain positions of power. It is a social activity by a subordinate to a superior, requiring being in close presence of the person whose favor is desired. The object is to demonstrate dependency with the aim of eventually obtaining favors of the person depended upon (Bista, 1991). Bista (1991) argues that practices such as *Chakari,* along with the obligations and taboos that go with ethnicity are major barriers for Nepal's development and modernization. As we discovered during the course of this study, ethnic and caste affiliation was one of the most important factors determining how populations cope with economic and landslide risk (Sudmeier-Rieux et al. 2011 b)

With 103 ethnic and caste groups, a large spectrum of religions and languages , defining what constitutes a community, especially in Nepal is not an easy task (Gaboriaux, 1995; Wagle, 2010). According to Wisner (2003), one needs to be extremely cautious in using the term community, as it implies a certain sense of cohesion, the sense of togetherness and common purpose, which may be far from reality. The term community is often overused, especially in the NGO literature, where 'The Community' is considered the focus of NGO interventions, even if these are far from being homogenous units and at times filled with conflict, inequalities, historical problems, and even hostilities (Cannon, 2008). It is very difficult to generalize about ethnicity, castes and communities in Nepal, as some multiethnic communities are cohesive and others are extremely torn. In other words, even generalizations about defining traits, or sterotypes specific to ethnic groups or castes can be dangerous, but even more so for communities, unless they are very homogenous units. For instance, *Tamang* are known to eat pork and brew local rice wine; *Gurung , Limbu, Sherpas* are known for their strength and recruitment to foreign armies essentially comes from these ethnic groups; *Brahmin* is supposedly the 'pure' caste and most priests emanate from this group. However it is not uncommon for one 'community', especially in urban areas to be composed of a mix of *Tamang, Dalit* and *Brahmin*, as not all of people from this 'advantaged' caste are well-educated and well off. Communities in Nepal are therefore both melting pots and homogenous units; both cohesive units and incongruous assemblies of houses without a common social purpose (Bista, 2004).

2.4.4 Recent political developments related to land use and landslide management

Several recent political reforms and developments are noteworthy as they affect the framework of this study: the Natural Calamity Relief Act (1982), which gave importance to post disaster activities such as search and rescue (MoHA, 2009); the Forest Act (1993), handing over a majority of state forests and communities through the formation of community forest user groups; the Local Self Governance Act of 1999, assigning local level disaster related responsibilities to the regional and district levels; and the National Action Plan for Disaster Management in Nepal (1996), including plans for disaster preparedness response reconstruction and mitigation (MoHA, 2009). A decade of armed conflict came to an end with the abolishment of the centuries old Rana dynasty, bringing hope about a new era and a more participatory popular democratic rule (Sharma 2010). Yet, democracy came at a high price - over 10,000 deaths, thousands of internally displaced persons, many educated people fleeing the country and destroyed infrastructure worth millions of rupees. Current public opinion about the new government is split and largely criticized for poor governance and inability to pass the new CA and enact real reform (Bhattarai, 2010; Dhungel, 2010). Whether democracy has truly been installed is an open question, as the interim constitution has yet to be ratified by the CA, three years later. Yet, in a country with fledgling democratic traditions, over 100 ethnic and caste groups, a plethora of political parties and cultures, it may be understandable if democracy takes a while to root itself.

This post Monarchy period is marked by several important political developments: a strong push towards decentralization of power and budgets, in recognition of the need to grant greater power to remote areas; the inclusion of socially excluded and marginalized groups, as illustrated by a large number of female and disadvantaged CA representatives; and a pro-poor development strategy, which strongly encourages linking remote areas through road construction and re-distribution of land to marginalized populations. These developments have significant consequences for landslide risk management, as roads offer new economic opportunities through improved transportation and better access to markets but they also are increasing physical risks as populations are attracted to roadside settlements which are often dangerous places due to increased slope instability (Oven, et al., 2008).

2.4.5 Vulnerability factors and trends in Nepal

As outlined above in the brief overview of recent historical developments, Nepal has undergone considerable environmental changes over the past decades largely due to three main driving forces: population change, market forces and state interventions (Jodha, 1995). Nepal has evolved from a largely feudal country in the 1950s to a modern state, albeit one with continuing government instabilities and ensuing lack of governance at all levels. This lack of guidance, together with a movement toward decentralization begun in 2008 has translated into a lack of coherent local development strategies. No local elections have taken place in the past five years and the usual five year development plans have been substituted with one year plans. Rather than reflecting real development needs, these plans result from demands made from vocal constituents and influential political parties who negotiate budget allocations and development priorities.

The first driving force is population change, created by both push and pull factors (Hoermann, Banerjee, & Kollmair, 2010). The main push factors are low food security, epidemics and disasters. Over the past two decades, Nepal has changed from a net exporter to a net importer of food and although recent data suggest that the trend that food insecurity may be decreasing mainly due to remittance income (Adhikari, 2011; Khanal, 2011). According to CBS data (2009b), arable land per 100 persons has declined in Nepal between 1990 - 2007 from 9.4 to 8.5 hectares (ha). The proportion of the population living in rural areas remains high, 83% in 2008, a decline from 91% in 1990, with a total population of 23.1 million (CBS, 2009a).

Reasons for this food insecurity are multiple: declining agricultural productivity due to the high cost of fertilizers, unequal access to land, rising food and commodity prices, heavy dependence on food and oil imports, high transportation costs and inaccessibility of remote mountains and Western Nepal, declining long term trend in public investment, agricultural support services and outreach (Hoermann, et al., 2010). To this, we add lost agricultural land and income due to natural hazards, especially drought, landslides and flooding. According to the NLSS 2003- 2004 study the average Nepali household spends on average 59% of their total expenditure on food, the poorest quintile of the population spends as much as 73% (CBS, 2004).

The second push factor is epidemics and disasters, which are estimated to affect over 127,000 people on average every year, aggravated by a lack of quality healthcare in rural areas. Diseases, notably cholera, gastroenteritis, encephalitis, meningitis, diarrhoea, skin diseases and pneumonia are common (MoHA, 2009). Epidemics are the number one killer in Nepal with an average of 420 adult deaths per year and 28,000 children dying from diarrhoea every year (MoHA, 2009). Unsafe drinking water and poor sanitation are the main causes of most diseases and are most common at the height of summer monsoon season. Indoor pollutants due to the common use of indoor open fire stoves expose people to harmful contaminants, causing higher rates of acute respiratory infections. Poor hygiene and inappropriate handling of chemicals also cause a very high incidence of skin diseases (MoHA, 2009).

2.4.5.1. Migration trends[2]

By 2001, 1.7 million people had migrated to a different region than that of their original place (Table 10). Of the total population (5 years and above) 37 percent have migrated from other places (VDC, municipality or outside the country) to their current place of residence (CBS, 2004). Half of those who migrate are women, mainly for marriage related reasons necessitating females to migrate to their husband's place of residence. Since the eradication of malaria in the 1950s, the Terai and urban areas (77%) have been those areas receiving the highest number of migrants, mainly from the Hill regions (CBS, 2009) (Table 10). After marriage, which account for 80% of migration in rural areas versus 54% in urban areas, other reasons for migration are economic (19%) and education (2.6%) (CBS, 2004).

[2] This setion has been published in Sudmeier-Rieux et al. (In press (a))

Origin	Destination				% Out-migration	Net Migration
	Mountain	Hill	Terai	Total		
Mountain		125,597	169,825	295,422	17.1	(255,103)
Hill	33,895		1,157,035	1,190,930	68.9	(830,759)
Terai	6,424	234,574		240,998	14.0	1,085,862
Total	**40,319**	**360,171**	**1,326,860**	**1,727,350**	**100.0**	
% Immigration	2.3	20.9	76.8	100.0		

* This figure does not include the movement of people within a region.
Source: CBS (2003) p. 134.

Table 10. Migration of population, Nepal, 2001 (from CBS, 2009a)

2.4.5.2. Remittance trends

As for pull factors causing migration, emigration outside of Nepal has grown exponentially in importance especially in the past decade. In 2008, over 30% of all households received some form of remittance, and 23% received a remittance sent from abroad (Table 11). Hoerman and Kollmair (2009) report that in Nepal's Hills, the figure is even higher, half of those households surveyed received remittances representing close to 35% of their income. Income received from abroad (83.2%) has significantly surpassed that received from within Nepal.

Description	*Nepal Labour Force Survey 2008*
Percentage of households receiving a remittance: from either absentee or other	*30.0*
Percentage of households receiving a remittance from abroad: from either absentee or other	*23.0*
Average remittance received in the last 12 months (total) by households receiving remittance (NRs)	*65,755*
From within Nepal	*28,976*
From outside Nepal	*80,462*
Average remittance received in the last 12 months (total) over all households (NRs)	*19,721*
From within Nepal	*3,366*
From outside Nepal	*16,355*
Share of amount of remittances received by household: From within Nepal	*16.8*
From outside Nepal	*83.2*
Total	*100.0*
Share of amount of remittances received by household from outside Nepal	*100.0*
From India	*13.4*
From Malaysia	*19.2*
From Saudi Arabia	*14.9*
From Qatar	*21.3*
From United Kingdom	*2.2*
From other countries	*29.0*
Per capita remittance amount for all Nepal (nominal NRs.)	*4,042*

Note: Nominal Rupees are values in current prices without adjustment for price changes over the period.

Table 11. Data on remittance income for Nepal, 2008 (from CBS, 2009b)

The country from which the highest amount of remittances are sent is Qatar (21.3%), followed by Malaysia (CBS, 2009b). The average remittance received for Nepal is high, over 65,000 NPR (USD $928) annually per household (4,042 NPR, or USD $58 per capita), as compared to average household income for Nepal, which was 80,000 NPR (USD $) 1142in 2003/4 (CBS, 2009b). If the new data from NLSS III are confirmed then remittance income has increased to an impressive 9,245 per capita (USD $ 135) and average household income to 202,374 NPR (USD $ 2,891) per household in 2010/2011 (CBS, 2011). It important to note the large variation in the remittances received, depending on the education level of the immigrant and the type of work secured abroad. Certainly this trend has been reinforced by a parallel boom in the number of mobile telephones, estimated at 25% of the population in 2008 (CBS, 2009b) and the large number of youths connected to social networks. Even for those living in remote areas, there is often an Internet café, booming with young people searching for foreign employment, foreign scholarships, or 'chatting' with their newly immigrated relatives.

On an aggregate scale, remittances constitute a significant inflow of cash in the country, even surpassing the amount of foreign aid received (Adhikari, 2011)(Figure 18). In 2007, approximately USD $3 billion in remittances were sent to Nepal, as compared to the USD $1 billion received in foreign aid (Hoermann, et al., 2010). According to the latest figures, this amount has risen to USD $ 3.7 in 2011 (CBS, 2011). The amount for Nepal is extremely minor as compared to neighboring China (USD $ 23 billion) and India (USD $ 26 billion) in absolute numbers but is significant in the Nepal context. Remittances are thus a major pull factor for mainly rural Nepal, injecting needed capital into the economy but also creating other vulnerabilities as migrants, usually men are often absent for periods of three years. They leave behind mainly women and older people to run the farms, maintain terraces, care for livestock, etc. (Hoermann, et al., 2010). The consequences are yet to be fully appreciated but it is likely that some fields may be abandoned, terraces less well-maintained, and a likelihood of increasing landslide risk (Fort, et al., 2010).

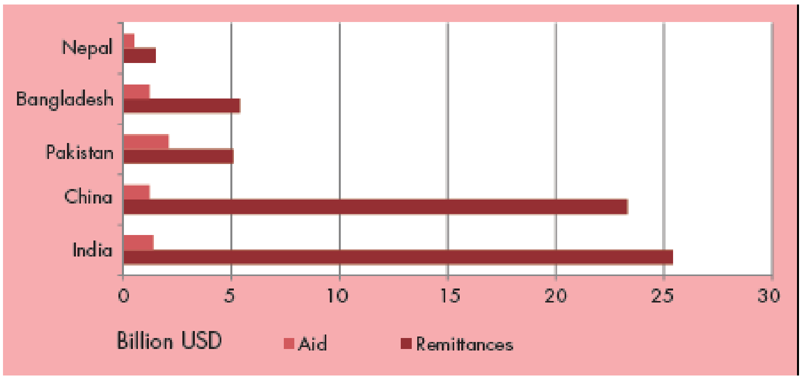


Figure 18. Remittances for selected Asian countries in 2007 as compared to foreign aid (from Hoerman, et al. 2010, with data from the World Bank).

2.4.5.3. The road construction boom

Another major trend in Nepal's rural development is the exponential pace of rural road construction, another pull factor leading to out migration of rural areas. As a result of the 2008 Decentralization Act, as described above, significant authority and budgets have been transferred to local government. As a consequence, rural road construction has become the main priority of the Village Development Committees (VDCs), and District Development Committees (DDCs), the main village and district authorities. Many communities, eager for the perceived opportunities of a road are collecting their own funds to rent bulldozers. Rural Nepal is thus undergoing a boom in rural road construction, largely built without proper technical guidance, surveying, drainage or structural protection measures. Between 2006 and 2008, the number of earthen roads increased by over 12% and it is likely that this figure will increase even more (CBS, 2009a). The result is that many of these roads collapse during the first monsoon rains and a sharp increase in the number of roadside landslides. According to unofficial statistics by the main technical officer at the Dolakha Soil

Conservation District Office, 25 out of 32 registered landslides in 2010 were due to improper rural road construction (Dolakha District Soil Conservation District Officer, 2011).

This brief historical outline of the social economic and political situation in Nepal and main trends affecting rural Nepal was intended as a background for better understanding disaster risk management in Nepal, which will be covered in the following section.

2.5 Disaster risk management in Nepal

2.5.1. International level

The Hyogo Framework for Action (HFA) , 2005-2015 is a non-binding international guidance tool which seeks to reduce the human, social, economic and environmental costs of disasters. The U.N. International Strategy for Disaster Reduction (UNISDR) is the main agency mandated to support implementation of the HFA. It does so through the establishment of national platforms for disaster risk reduction, which are intended as multi sectoral, multiagency platforms for integrating DRR into all aspects of development planning. There are now 60 such national platforms, some more active than others. For those countries that have not yet established such platforms, there are Hyogo focal points who are responsible for implementing the HFA (UNISDR, 2009a). There are regional platform meetings and biannual global platform meetings to convene national platforms and assess progress toward the HFA goals. The biennial Global Assessment Report summarizes progress made towards national DRR goals, highlights major drivers of risk, areas with continued high risk, vulnerabilities and exposures. Nepal is a signatory of the HFA and as a consequence has its own national platform for DRR: the National Disaster Management Authority. How Nepal attempts to implement HFA goals, through various agency initiatives is described below.

2.5.2. National and district levels

At the national level, there are several government agencies involved in DRR, and at the center is the Natural Disaster Relief Committee (NDRC) which forms a hierarchy of committees for dealing with disasters (MoHA, 2009). It is the main body mandated in Nepal to carry forward the HFA. A National Disaster Management Council is being planned which would replace the NDRC and become an inter-agency coordinating committee also focusing on prevention. Main government agencies are:

- **Ministry of Home Affairs:** the central agency for disaster management. It implements national policies and carries out immediate rescue and relief work.
    - At the district level, it houses the Chief District Officer (CDO) who is the main local authority with oversight over requests for compensation due to disasters.
    - Armed Police Force: is often the one to be conducting rescue and relief and therefore plays a major role for ordination of post disaster situations.
- **Ministry of Water Resources**: is responsible for planning and policymaking and implementation related to water resource projects. It receives advice from the Water and Energy Commission Secretariat (WECS), a multi-

disciplinary institution which conducts research and investigation on water and energy issues to support government policymaking.

- **The Department of Water Induced Disaster Prevention**: its goals are to identify potential disaster zones, establish early warning systems and reduce social and economic losses due to disasters. This division is mandated to prepare disaster management policies, carry out hazard mapping and zoning, prepare floodplain action plans etc. It is the main agency involved in landslide mitigation for large landslide especially by major roads. However it only has five regional offices and is not able to address a fraction of all landslides as needed.
- **Ministry of Forest and Soil conservation:**
  - Department of Forests: the main department in charge of community and state forests.
  - Department of Soil Conservation and Watershed Management: this agency has a key role in improving land use and agricultural productivity assisting communities to meet their basic needs. As they have many district offices and a very good technical understanding of shallow landslide mitigation using bioengineering methods. However due to their lower importance and budgets, their good advice on bioengineering methods for road construction is often not heeded.
- **The Department of Hydrology Meteorology**: this department plays a critical role by maintaining a network of climatic and River flow gauging stations. Lack of instruments for collecting hydro-climatic data due to insufficient budget are its main problems.
- **The Ministry of Local Development (MOLD)**: this ministry is often not mentioned in connection with DRR. It may however be the most important as it receives the largest amounts of government budgets through local governments and even more so since the 2008 change of government. More importantly it is this ministry that receives the budgets and decided over priorities for critical local development: school construction, district and village level road construction, health clinics, village sanitation, drinking water (MoHA, 2009).

At each regional, district and village level there is a disaster management committee, at least the intention is that there be one even at the village level. This varies considerably from district to district. The Nepal Disaster Management Council faces many challenges in addressing the many disasters and logistics for coordination (IFRC, 2011). Until recently it has mainly been addressing post disaster situations but is becoming more active in prevention, especially with the assistance of a number of international NGOs and an umbrella organization focusing on prevention: Disaster preparedness network. We list some of these other actors below.

Other actors in disaster management.

As government budgets are limited, international agencies and NGOs play an extremely important role for disaster risk reduction in Nepal. These include but are not limited to:

- Disaster preparedness network, an umbrella organization for coordinating disaster prevention;
- The Nepal Risk Reduction Consortium, an interagency (UN, NGO) consortium, mainly concerned with earthquakes and flooding.
- UN agencies: UNDP, UNOCHA;
- Nepal Red Cross /Danish Red Cross;
- International NGOs: Oxfam, CARE, Practical Action, Mission East

- National Society for Earthquake Technology, Nepal
- ICIMOD, a research center with extensive documentation on climate change, vulnerability and migration issues.
- National Victims of Disasters Society:
- Nepal Landslide Society;
- RELIEF, an international project for developing a series of risk assessments in Nepal.

2.5.3. Challenges for landslide risk management in Nepal

Considering the difficult current economic and political situation of today's Nepal, disaster prevention is a challenge, whether for flooding, landslides or forest fires. In most of the world, including Nepal, disasters are still perceived as exceptional natural events that interrupt normal human development and require humanitarian actions to mitigate loss (UNDP,2004). Landslides present an extra challenge as they represent extensive risk, versus flooding which is intensive risk (UNISDR, 2011). Floods often occur in more densely populated river areas in the plains , which provide easier access for NGOs, government agencies and media, who are good at beaming across pictures of flood disasters. Whereas landslides occur in remote areas, are underreported by a factor of two, usually affect livelihoods more than causing casualties, and as a result very few agencies or organizations address landslide risk. All the international NGOs listed above are mainly concerned with flooding and basic development needs. The two agencies which could play a larger role, the Department of Soil conservation and the Department of Water Induced Disaster Prevention are very underfunded and lack the clout of the other departments. As we end this chapter with a quote:

"*The question be asked, when millions of people and children are suffering from malnutrition, hunger, and are struggling for their daily, basic food requirements for mere survival, how can we spending money on anything else, leave apart disaster management. But it is ironical and sad that in these countries whatever financial resources are available for this job are misutilized either due to corruption or due to lack of vision. Is it not sad and disheartening that [..] the people who had suffered from the disaster are making the same mistakes; activities like improper drainage and sewage facilities, unsafe housing and construction, deforestation and devegetation of slopes, etc. are carried out by the same people in the same area which had earlier suffered from the disaster. Thus unless these behavioral and psychological attributes of the people are not changed through education and awareness, landslides or other such disasters cannot be managed, let alone avoided*" (Singh, 2010) :130.

Literature Review

3.1. Risk

"To the extent that risk analysis is precise and simple, it is not real.
To the extent that risk analysis is real and complex, it is not precise."
Haimes, 2009a

Risk is part of everyday lives, especially in mountain areas of Nepal: the primary factor being securing sufficient means for livelihoods. Flooding or landslides are certainly frequent, or extensive risks, which often take second priority, compared to food security or access to roads, according to our research and confirmed by others (Hewitt, 1983; Lewis, 1999; Nathan, 2008). They are monitored and surveyed by the population, but usually no action is taken until a point when the hazard threatens human life. For landslides, usually the only actions undertaken are to monitor movement, plant bamboo or construct minor mitigation structures. In order to understand how to manage hazards in this context, we need to understand the livelihood context and multiple risks faced by mountain populations. This section begins with definitions of risk, an overview of the literature on risk, risk perceptions and coping with risk, risk models and we end with a discussion of how risk is applied, risk assessments and risk management.

Research on risk and physical hazards is gaining significance with the increased frequency of exposed elements and predictions of increasing numbers of extreme events due to climate change (UN/UNISDR, 2009). One of the main difficulties of interdisciplinary research is coming to agreement, or agreeing to disagree, about the definition of terms. This holds especially true for the complex and multi-disciplinary field of risk management. Risk in disaster risk reduction (DRR) terms is usually defined as the intersection between vulnerability, exposure and hazards. It is an expression of future potentiality of a catastrophic event and can be expressed either qualitatively or quantitatively. The term is often attributed to Rousseau who deplored the Lisbon earthquake disaster of 1755 and the human responsibility that allowed the construction of 20,000 houses six or seven stories high (Bourg, 2007). In parallel, the term was developed for the maritime industry to calculate the cost of lost cargoes with the frequency of storms, or piracy (Bernstein, 1998). The nuclear industry brought a need to have more accurate risk calculations to forecast costs and frequencies of potential accidents, especially to reassure anxious communities (Slovic, 1987; Slovic et al. 2000). Yet risk is much more than just potential losses. According to Lenk (2007), the analysis of risk goes well beyond mathematical computations of probability to dealing with multiple actors, responsibilities, social and cultural contexts and individual prejudices.

3.1.1. Defining risk

UNISDR (2009b) defines risk as: "*The combination of the probability of an event and its negative consequences*". According to UNISDR, the word "risk" has two distinctive connotations: "in popular usage the emphasis is usually placed on the concept of chance or possibility, such as in "the risk of an accident"; whereas in technical settings the emphasis is usually placed on the consequences, in terms of "potential losses" for some particular cause, place and period. It can be noted that people do not necessarily share the same perceptions of the significance and underlying causes of different risks." This definition provides a more nuanced interpretation from a previous UNISDR (1992) definition: "*the expected number of losses of human life, injured, damage to goods and economic activity during the period of reference and a given region caused by a natural or human-induced phenomenon*." Risk is above all an anthropocentric notion; risk only exists in relation to humans, human activity or something valued by humans (e.g. biodiversity). It can be expressed either qualitatively or quantitatively in terms of loss, usually: fatalities or economic losses. A hazard, such as rock fall or an avalanche does not constitute risk if there are no negative consequences or probability of human-related loss.

Risk is therefore an expression of future potentiality of a catastrophic event, dependent on a hazard (H), which can be a small or large "physical" event (Textbox 1); vulnerability (V) of physical infrastructure or a population and exposure of the infrastructure or population, which includes a variable of temporality. The element at risk (E) is often included in exposure but can also be expressed separately (see equation below). This element is a critical, often overlooked aspect of risk and there are unfortunately many examples of public and private infrastructure causing risk because of poor planning or risk assessments.

$$R = H * V * E$$

While a more quantitative equation developed for landslide risk is given as:

$$R = H_{DI} * Exp * V_{DI} * W_{DI}$$

H = Hazards [probability of a danger D of intensity I]
Exp = Exposure [% of population exposed, time spent in houses]
V = Vulnerability [% of destruction of an element or physical structure of a danger D of intensity I, or % or population affected]
W = Potential losses [$ or deaths]
(Fell & Hartford, 1997)

From an engineering or systems perspective, which has traditionally dominated the risk management field, "risk is a measure of the probability and severity of adverse effects" (Lowrance, 1976) as quoted by (Haimes, 2009a). This seemingly simple and clear definition also poses problems as we can ask what we mean by probability and what we mean by adverse? Probability is an abstract term by nature to quantify the level of confidence that we have in the information (Haimes, 2009a). According to Haimes (2009a), the phrase can be interpreted in two ways at the same time: i) in terms of the probability of occurrence of adverse effects; and ii) in terms of the probability of the severity of adverse effects, given their occurrence; both are valid however with different conceptual and theoretical challenges.

According to (Jaboyedoff, 2010) "*This viewpoint is still valid, but has rarely addressed the problem of the indirect impact on the society and the economy. The above formulation does not take this point into account, because it relates only to the direct effects of catastrophes. It only takes an estimate of the costs of reconstruction or life-prices. This is relevant but must be modulated by the evolution time for the recovery period.*"

Under such condition the total cost (TC) of a catastrophe must be evaluated by:

$$TCi = Ri + PCTi$$

Where PCT represents post catastrophe costs. As we will see in section 3.6, resilience, corresponding to the recovery period, can be then introduced as the quantification of the disruption and its evolution over time.

3.1.2. Assessing and managing risk

> **Natural versus physical hazard events**
>
> The 2nd ISDR Global Assessment Report (2011) uses the term physical hazard vs. natural hazard to describe hazardous phenomena such as landslides, storms and drought. The reason is that more and more hazards are no longer natural but rather a result of urbanization, environmental degradation and climate change effects.
>
> (UN/ISDR, 2011)

Textbox 1

One critical aspect risk reduction is the risk assessment phase, which can be conducted based on qualitative data in a participatory manner as part of a community based risk assessment, or quantitatively. For both quantitative and qualitative cases, the risk assessment needs to take into account the system and its interactions with its environment and can be based on developing scenarios with varying probabilities. Four basic questions are asked, which can apply to all types of risk assessments:

- What can go wrong?
- What is the likelihood?
- What are the consequences?
- Over what time frame? (Haimes, 2009a).

To which we add: how much will it cost to mitigate and how to prioritize multiple risks, how much risk is a society willing and able to accept?

3.1.3. Tolerable and acceptable risk

A common component of land use plans is to identify and negotiate "tolerable risks", which are "risks within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further of possible"(Leroi, Bonnard, Fell, & Mc Innes, 2005). On the other hand, 'acceptable risks' are 'risks which everyone affected are prepared to accept'. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort" (Leroi, Bonnard, Fell, & Mc Innes, 2005). The International Union Geological Society (IUGS, 1997) has published general criteria on tolerable risk. One specific criteria that they promote is that risk from a hazard should, wherever reasonably practicable, be reduced, ie. the As Low As Reasonably Practicable (ALARP) principle should apply (IUGS, 1997). To sum, these principles are about establishing a bottom line on how much a society is willing or able to pay to ensure the safety of its citizens. There are obviously great differences between ALARP principles in a developing and developed countries, and among developed countries, generally depending on economic well-being, systems of ownership and cultural considerations (Leroi, Bonnard, Fell, & Mc Innes, 2005). Responsibilities for risk reduction therefore differ considerably among countries due to differences in resources, governance issues and the level of services that public agencies are able, or expected to deliver.

3.2 Risk management

Risk management obviously has different connotations for the financial, insurance and disaster management sectors. We are here mainly concerned with improving ways of managing and reducing risks related to physical hazards, notably landslides. The goal of risk management is to anticipate and estimate risk, while disaster management refers to both the anticipation of hazards (ex-ante) and managing the aftermath (ex-post). Figure 19 shows the risk components, as defined by UNISDR (2009b), with examples of mitigation measures. As mentioned previously, more emphasis needs to be placed on exposure, as a critical, often overlooked aspect of risk. Human settlements and most of the world's population are naturally situated in exposed areas, near rivers or coasts because of the economic opportunities they bring. With population growth and increasing sea levels, exposure is likely to increase. Thus effective risk management should address all aspects of risk, not only the hazard and population segments, as is often the case.

Leroi et al. (2005) define landslide risk management, whether of natural or anthropic origin, as *"the systematic application of management policies, procedures and practices to the tasks of identifying, analyzing, assessing, mitigating and monitoring risk"*. There are several approaches to managing risks due to physical hazards, some which will be described in the following sections.

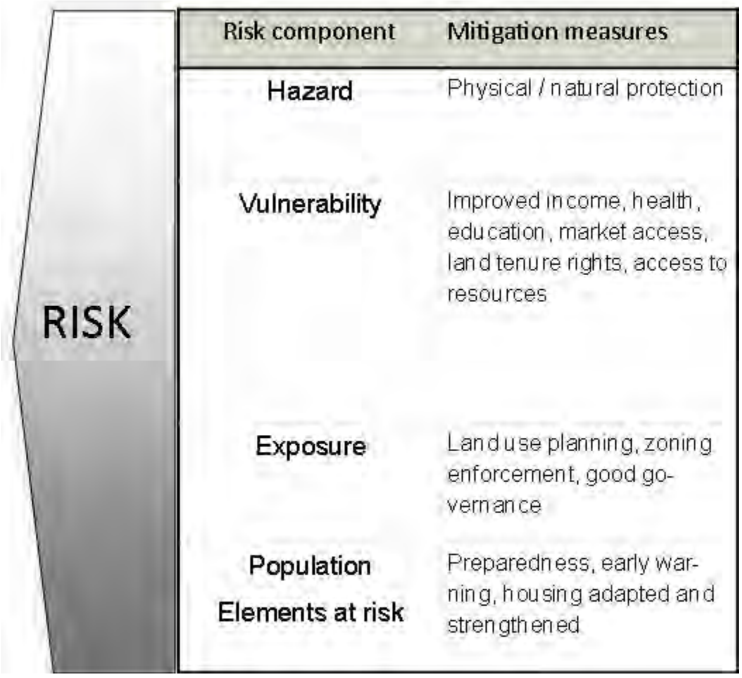


Figure 19. Components of risk and examples of mitigation measures

3.2.1. Disaster risk management versus disaster risk reduction

Compared to the concept risk, which is a measure of likely adverse effects, a disaster is the sum of consequences or the realization of risk. Disasters are usually the consequence of a society unable to manage or cope with a physical hazard, which "*seriously disrupts the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources*." (UNISDR, 2009b).

Although the term "disaster risk" would appear as a contradiction between the consequence of a disruptive event and the evaluation of potential damages, it is commonly used by policy makers and NGOs. Disaster risk management (DRM) and disaster risk reduction (DRR) signify efforts to manage and lessen the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness. In the policy and NGO literature, DRR is now more commonly used, reflecting a greater shift toward prevention and reduction of risk, rather than management of risk. We refer to DRR as the combination of investments and actions to reduce the consequences of disasters, through risk assessments, risk management, capacity-building, monitoring and preparedness. Integrated disaster risk reduction also has different meanings but usually refers to the integration, or combination of social, economic, physical, environmental, political and psychological aspects of disaster preparedness, prevention and response.

The disaster management cycle is commonly used to schematize the process of managing disasters, usually depicted as a self-containing cycle (Figure 20) with four phases: response, recovery, mitigation, preparation. The critique against this schema is that it always returns to the disaster event, without necessarily improving the process. The alternative disasters cycle is also an utopic over-simplification but it suggests an alternative process whereby “sustainable development” and risk reduction are integrated to improve disaster management. This process should then move away from disasters, or at least improve the management of them. It is however more consistent with international policies that promote “mainstreaming” of disaster management with development.

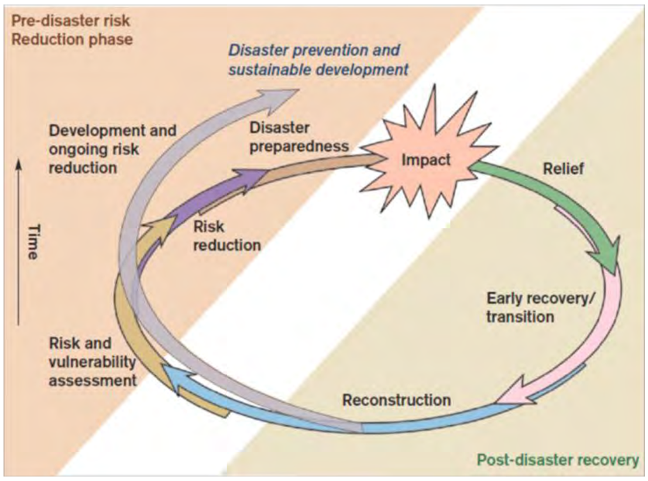


Figure 20 Left: Disaster management cycle (http://pre-drp.org); right: Alternative disaster management cycle, (RICS, 2009)

3.2.2 Integrated risk assessments

Over the past decades, a paradigm shift has occurred from the top-down hazard-oriented approach to disasters to the view that effective risk reduction needs to be integrated with sustainable development approaches (Birkmann & Wisner, 2006). It is now commonly agreed that disasters are “a complex mix of natural hazards and human action” often deeply rooted in social, economic and political processes that need to be understood for decision-makers and communities to address causes and if possible, to prevent or minimize new disasters (Burton & Kates, 1964; Hewitt, 1997; White, 1963; Wisner, Blaikie, Cannon, & Davis, 2004).

One method of preventing, predicting and managing landslides is through integrated risk assessments for understanding the geological, environmental and social contexts in which landslides occur (Crozier & Glade 2004; Leroi et al. 2005) (Figure 21). Integrated risk assessments require bringing together data across disciplines. Methods for each context are not new but the novelty lies in the interdisciplinary coordination. Proponents argue that even if upfront costs on integrated risk assessments can be time consuming and costly, this investment is necessary in order for prevention measures and reconstruction efforts to be effective and sustainable (Zimmermann & Issa, 2009). However more examples are needed to illustrate how to operationalize risk assessments, especially in data poor environments (Cardona, 2004).

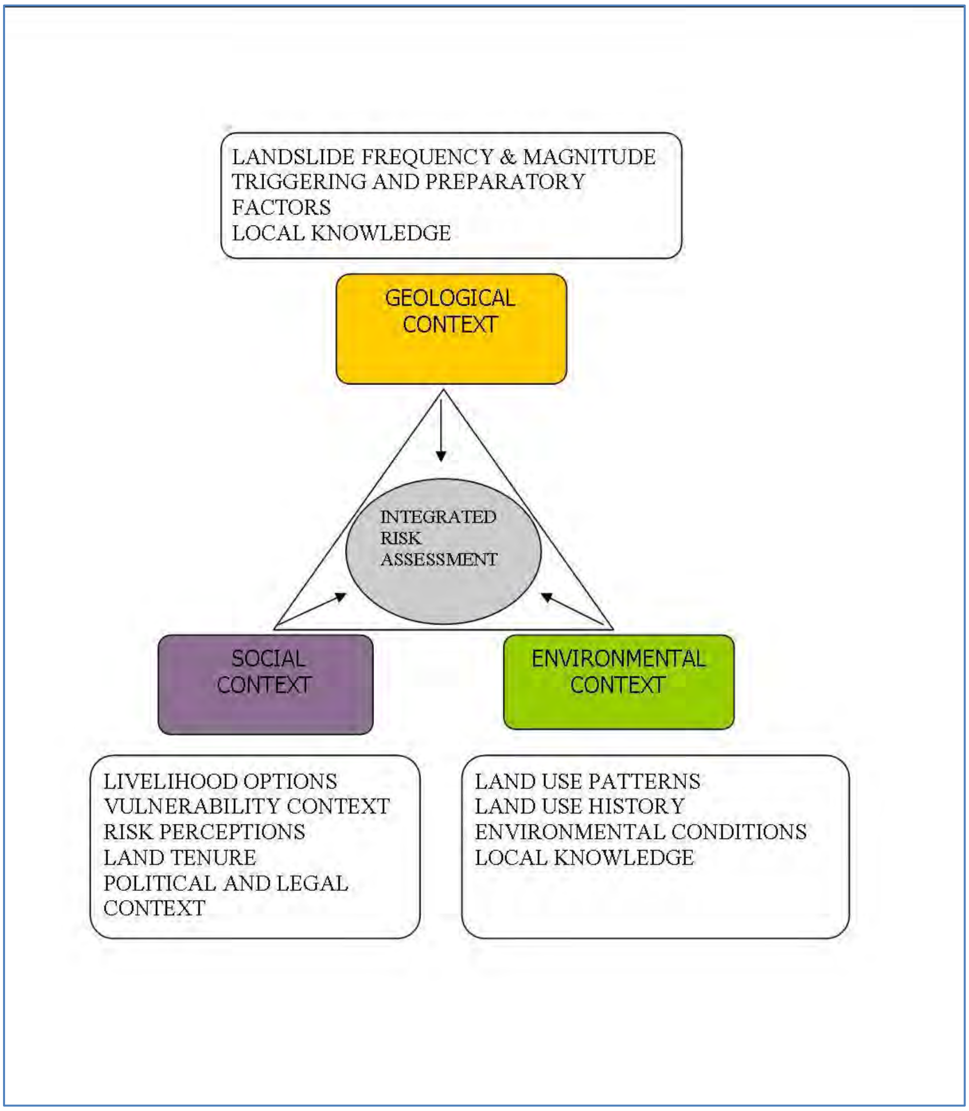


Figure 21. Integrated risk assessment, modified from Leroi et al. 2005 (from Sudmeier-Rieux et al, 2011)

3.2.3. Community based disaster risk reduction

Community based disaster risk management and integrated risk assessments are being increasingly promoted as more holistic and sustainable approaches to understanding and addressing risk (Bollin & Hidajat 2006; Kafle & Murshed, 2004; Khan & Mustafa, 2007; Wisner, 2006). It is in the context of promoting self-reliance that community based disaster risk reduction (CBDRR) has gained interest by NGOs and governments with an emphasis on enhancing community capacities to address disaster risks (Van Aalst et al., 2008). Initially coined by authors such as Anderson & Woodrow (1998), it was first operationalized and promoted in the Philippines and throughout Asia by the Asian Disaster Preparedness Center and by many local NGOs. Today, CBDRR practices have been incorporated into many DRR practices by NGOs worldwide. For example, in Nepal the Ministry of Local Development is currently working with Oxfam and a consortium of International NGOs (INGOs) to develop local plans for disaster risk reduction. Organisations such as Action Aid and Practical Action have been working with communities affected by flooding and establishing local DRR committees, especially in the Terai region but little work has been undertaken with landslide affected communities. The basic idea of CBDRR is community capacity building and community organization for disaster risk reduction and to improve communications with disaster management authorities. To this end, it emphasizes participatory approaches and community involvement throughout the process.

Main steps for developing CBDRR include:

- selecting the community;
- rapport building and understanding the community;
- participatory disaster risk assessment;
- participatory disaster risk reduction, management and planning;
- building and training a community disaster risk management organization;
- community-managed implementation;
- participatory monitoring and evaluation.

(Abarquez & Murshed, 2006)

Although most CBDRR approaches are qualitative, it is possible to combine community based, participatory approaches with quantitative methods. A quantitative community-based approach is proposed by Bollin and Hidajat (2006). "Community based disaster risk index" was developed to improve the capacity of communities and local government to measure key elements of their risk management strategies (Bollin and Hidajat, 2006). They developed 47 indicators, arranged according to main components of risk: hazard, exposure, vulnerability and capacity & measures. Weights were assigned by local experts and data were collected using questionnaires. Finally, scores were obtained and weighed for two different districts in Indonesia, permitting a comparative analysis. This system although intended to be participative relied on experts for developing indicators and weighting, possibly introducing a measure of bias. The risk index is however interesting as it allows a comparison between communities and offers a model for the risk-resilience index developed by this study.

3.2.4. Ecosystem based disaster risk reduction

The Global Assessment Reports in 2009 and 2011 highlighted that environmental degradation is one of the main drivers of risk, together with urbanization and poverty. Ecosystems provide valuable services for hazard mitigation, which until now have been under-utilized by disaster risk reduction programs and strategies (Sudmeier-Rieux et al., 2006). Ecosystems serve as natural infrastructure that can buffer the effects of natural hazards, and contribute towards overall vulnerability reduction: healthy and well-managed ecosystems sustain livelihoods and provide critical goods and services that help communities to cope with and recover from disasters.

Ecosystem-based disaster risk reduction includes the sustainable management, conservation and restoration of ecosystems to provide services that mitigate hazards, reduce vulnerability and increase resilience of populations (see sections 3.4 and 3.5 for definitions). In some cases, ecosystem thresholds may be surpassed depending on the type and intensity of the hazard event and/or health status of the ecosystem, which may therefore be insufficient to provide adequate buffer against hazard impacts. For instance, mangroves may not provide as much protection against tsunamis as they would for storm surges. Sometimes combining ecosystems-based approaches with human-built infrastructure (e.g. embankments) may be necessary to provide protection of critical assets, while providing livelihoods assets to populations. It is intended as an approach to be promoted in parallel with other community based a approaches to disaster risk reduction, such as strengthening early warning systems and disaster preparedness (Sudmeier-Rieux et al., 2006; Sudmeier-Rieux and Ash, 2009).

3.2.5. Territorial approach to risk

One example of risk management comes from the French spatial-territorial approach e.g. (Metzger & D'Ercole, 2009; November, 2007; Pigeon, 2009), which emphasizes the interconnections between land use planning, water management, public and private infrastructures, political interests and risk management. A territory can follow administrative boundaries, i.e., a "department", or natural boundaries, i.e., a watershed. Multiple types of risks are evaluated for the entire territory, considering trade-offs and costs (i.e. constructing a roads across an unstable slope to cut travel time). The product is a PLU (Local Urban Plan) or a PPR (Rural Protection Plan). However, this approach is criticized for taking an overly utilitarian engineering and economic approach, without sufficiently taking into account public opinion or public knowledge.

3.3. Risk perceptions, coping strategies and risk priorities

3.3.1. Theoretical overview of risk perceptions

Risk perceptions are the judgments people make when they are asked to characterize and evaluate hazardous activities and technologies (Slovic, 1987). How people perceive risk is at the heart of the literature explaining how individuals or groups contribute or detract from effective response and investment in risk reduction (Tierney, 1999). Theories explaining risk reducing (or augmenting) behaviors and choices, have emanated from at least five disciplines: psychology, sociology, anthropology, human ecology, political economics, with a number of cross-disciplinary convergences. Each approach describes various factors that determine how individuals and societies view and act upon risk.

Sociologist Ulrich Beck, in his seminal work, "Risk Society" (Beck, 1992) raised important issues about power and communication in risk assessments concerning mainly technological risks and the roles of scientists, government authorities and the media in defining and managing risks (Liverman, 2001). Instead, he advocated for greater public participation in decisions about environmental risk and models for involving stakeholders in both risk estimation techniques and management decisions. An important body of work on risk perceptions was developed by psychologists such as Slovic and Fischhoff (Slovic 1987; Slovic et al. 2000). Some of this work was financed by the nuclear industry and demonstrated how the public perceived collective risks, such as nuclear power or toxins in the environment, amplifying them, compared to more individual risks such as smoking or driving (Parkhill et al., 2010). "*Research demonstrated that people rank risks not only on scientific studies of the probability of harm, but also on how well the* *process is understood, its visibility and association with cancer, the degree of catastrophe, how equitably the danger is distributed, how well individuals can control their exposure, and whether risk is voluntary or imposed*" (Liverman, 2001).

The social constructivist approach explains risk as a collective social product, where risk is appropriated as one of many risks of everyday life (Lupton, 1999; Wynne, 1992, 1996). Kasperson introduced the notion of 'social amplification of risk' which suggested that the media, government, and nongovernmental organizations, as well as public arguments among scientists, can significantly increase or decrease public risk concerns (Kasperson, Kasperson, & Turner, 1995). These studies ensured that the processes of public involvement in risk assessment have become mainstreamed in many countries and jurisdictions (Liverman, 2001).

Anthropologists Douglas and Wildavsky (1982) propose four different types of cultural responses to risk depending on levels of group cohesion and expectations of authorities for reducing risk: fatalistic, egalitarian, hierarchical and individualistic. The human ecology approach regards social and environmental systems as coupled, with humans having a high capacity to adjust to environmental conditions (White, 1942; Kates 1971; Burton et al. 1993). Political-economists, spearheaded by Sen (1982) and the "entitlement approach", tend to minimize the role of risk perceptions to explain how marginalized people make choices about living in dangerous places. Rather, they link disasters to everyday risks and development, pointing to structural inequalities and a lack of access to resources to explain why marginalized populations are most vulnerable to hazard events (Sen, 1982; Sen, 1999; Wisner et al., 2004; Cannon 2008). Gender and ethnic factors are important cross-cutting issues that determine how women (Cannon, 2002; Enarson & Morrow, 1998; Enarson & Fordham, 2001; Fordham, 2004; Neumayer and Plümper, 2007) and marginalized ethnic groups (Bosher et al., 2007; Lazarus, 2011) often face a higher risk situation due to social norms, lower access to information and education.

A common thread of these approaches is that risk is contextual and depends on cultural beliefs and social goals, which cannot be proved or disproved (Hewitt, 2009; Lupton, 1999; Quantarelli and Dynes, 1972). Two arguments from this literature are of particular interest for our study: a discord between layperson perceptions of risk and "scientifically established" risk; and a discord between risk perceptions and risk reducing actions or behavior (Beck, 1992; Douglas and Wildavsky, 1982; Wynne, 1992). These discords describe a frequent misperception that heightened risk awareness through scientific knowledge will invariably lead to a "rational" decision, such as moving to a safer place (Cannon, 2008; Gaillard et al., 2010; Lupton 1999; Wynne, 1996).

For marginalized people this is unlikely to be the case (Gaillard and Cadag, 2009; Nathan, 2008; Oliver-Smith, 2002). On the contrary, people who depend on natural resources for survival are likely to be highly aware of physical risks, such as cracks and bulging land, signs of potential landslides and have a clear idea about which households in their community are most at risk. Many poor households may have little choice but to accept and take responsibility for physical risk alongside economic risks (Bohle and Adhikari, 1998; Cannon, 2008; Cannon and Müller-Mahn 2010; Giddens, 1999). We find here parallels with Maslow's landmark "Theory of Human Motivation" (Maslow, 1943), where physiological needs must first be met before all other needs, including safety (Figure 22).

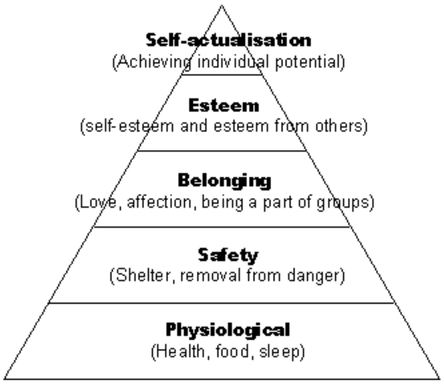


Figure 22 Maslow's hierarchy of needs (modified from Maslow, 1943)

Thus risk perceptions alone do not suffice to explain why certain risk mitigation programs fail and others succeed (Cannon, 2008; Nathan, 2008). As marginalized households cannot reduce all risks, they have to prioritize and chose which strategies will address their most pressing risks, or their "risk priorities" (Nathan, 2008). This is a different type of risk reducing strategy and rationale, described by Wynne (1996) as "reflexivity of lay people", where seeming "irrationalities", i.e. living in a landslide prone area, actually make sense for such communities considering their everyday life choices (Bankoff et al., 2003; Wynne, 1996).

According to Nathan (2010), *"risk perception thus obeys a universal law, previously demonstrated by the sociologist Pierre Bourdieu : the adaptation of expectations to opportunities (Bourdieu, 1992). People evaluate what is possible and what is not and model their expectations, objectives and hopes to this evaluation, which correspond to their objective possibilities according to their social position. Applied to the situation of the exposed people, this principle explains a certain resignation or acceptance of risk based on adaptive realism and the lack of alternatives… Understood in this manner, accepting disaster risk constitutes a more or less conscious strategy of resilience to other risks, which were presumably perceived as greater or more immediate (Nathan, 2008:353)."*

3.3.2. Critiques of risk perception

There are thus two main critiques of the term "risk perception": risk perceptions are not the main determinant of behavior of populations living in dangerous places. A second critique of the term "risk perception", especially among French sociologists is that the term is limited to a passive interpretation of risk, as compared to "representations of risk", considered a more holistic notion than risk perceptions (Peretti-Watel, 2000).

Rather than risk perceptions, this research focuses on "risk priorities" and "coping strategies", defined as the range of options, adjustments, decisions or choices that households and communities use to deal with adverse situations (Burton et al., 1993; UNISDR, 2009). The difference between "coping strategies" versus "coping capacities" is subtle, with "strategies" referring to an active decision-making process with an implicit awareness of choices, whereas "capacities" is synonymous to "abilities", a more passive term. Burton et al. (1993) distinguish between adaptation- and coping strategies as a function of the type of threat, and length of time required for a population to reduce risk.

Both require making adjustments to livelihoods based on decisions and choices following an appraisal of events and possible outcomes or consequences (Burton et al., 1993; Lazarus, 2010). Risk perceptions are considered one of several determinants of coping strategies.

Table 12 summarizes the theoretical and conceptual underpinnings of coping strategies. It is a proposed typology of coping strategies based on three categories of factors that determine coping strategies to risk: acceptance and actions to reduce risk; risk perceptions; entitlements and access to resources. As with as all schemes and typographies, the table is intended as a summary with the risk of oversimplification, especially regarding convergences between different theories. For example, not all households with high access to resources are individualists, with high expectations of government action. It is however useful as a conceptual framework with which we can compare research findings on coping strategies.

COPING STRATEGIES		FEW			MULTIPLE
RISK ACCEPTANCE, RESPONSIBILITY AND ACTIONS	Risk acceptance (Burton et al. 1993)	Deny risks	Passive acceptance	Acceptance	Active acceptance
	Actions (Burton et al. 1993)	Emergency actions only	Mainly emergency, some prevention	Preventive actions are taken	Drastic measures are taken to ensure safety
	Responsibility (Giddens, 1999)	Lies with community	Some government responsibility /community	Government responsibility / little individual responsibility	Entirely with government or market forces
RISK PERCEPTION	Cultural beliefs (Douglas and Wildavsky 1982)	Fatalists -Lack strong group cohesion -Little personal control over risk	Egalitarians -Identify with their group -Outsiders are blamed for risk	Hierarchists -Respect authority - High group norms	Individualists -Self regulation of risk
ACCESS TO RESOURCES	Political and economic factors: access to resources (Sen, 1982; Wisner et al. 2004)	Very low -Subsistence main priority over physical risks	Low to medium - Subsistence and physical risks	Medium to High -Greater concern with physical safety	High -Physical safety a priority

Table 12. Typology of coping strategies and determining factors, modified from Burton et al. 1993 (from Sudmeier-Rieux et al., 2011b).

3.3.3. Risk and culture

It is an open question whether culture can be separated as an autonomous determinant of risk or a subordinate element influenced by others, especially economic and social conditions (Hewitt, 2009). The conclusion of an e-conference in 2009 on culture and risk is that "*it is it is probably impossible and possibly dangerous to try to interpret cultural ingredients without reference to other elements such as the role of geography, local particulars of terrain, climatic variations, vegetation cover, and the history of environmental change* (Hewitt, 2009). "The 'locale' of events or settings plays an important role in shaping responses – for instance, rural versus urban, riverine, mountainous, etc.

"…*not only is it impossible and unwise to separate out culture (in the phrase 'culture and risk'), but equally problematic to differentiate between the risks of daily life and what are conventionally seen as 'disaster risks*" (Hewitt, 2009, p.6).

Thus, the relationship between culture is varied, complex and the literature on culture and hazards is not extensive, perhaps due to a certain negative bias towards cultural factors as leading to increased danger and loss. Negative examples of how cultural factors may lead to increased losses include the disproportionate number of women, elderly and children killed in the 2004 Indian Ocean tsunami, the Pakistan earthquake or many Asian cyclones due to lack of swimming skills, restrictive clothing or the unacceptability to join emergency shelters without a male chaperone (Gaillard, Sudmeier-Rieux, Kelman, & McAdoo, 2011). Inadequately considering religious beliefs about destiny or the 'cosmovision' of many indigenous populations of Central and South America Culture could be detrimental to effective DRR or recovery (Hewitt, 2009).

Cultural beliefs can also be advantageous to reducing risk. An often quoted example is from the Smong population Simeulue Island in Indonesia's Aceh province, where oral history about a tsunami 100 years ago reduced the number of casualties due to the 2004 Indian Ocean tsunami, compared to a neighboring village (McAdoo et al., 2006). Studies of hazards in Islamic countries show that although hazard events can be considered "divine punishment for sins", there is also recognition that community education about hazard mitigation, improved building construction and better care for the land would be beneficial to avoid further losses (Halvorson and Hamilton, 2010; Ghafory-Ashtiany, 2009; Paradise, 2005; Sudmeier-Rieux, et al. 2011a). Similarly, it is not fatalism or "cosmovision" that impede mitigation actions to reduce losses but rather the lack of resources for mitigation and willingness to properly take into consideration cultural differences and needs (Gaillard et al., 2010; Hewitt, 2009; Lopez-Mendoza, 2007).

3.3.4. Risk and responsibility

The issue of responsibility is crucial for establishing effective disaster preparedness, risk analysis and monitoring and will differ considerably between countries and cultures. Lenk (2007) enumerates three types of responsibilities with varying levels of formality: *collective responsibility,* which often represents an institution such as a public agency or private company, even if individuals may hold individual responsibilities within the institution. A group of individuals acting together will tend to be co-responsible for their actions and also act as a collective. The rules guiding collective action will obviously differ between countries and cultural norms. The second type of responsibility is *individual* and will differ for each role and task and can be legally binding, such as individual responsibilities to maintain fire safe buffers around each house in highly fire prone areas. The third level of responsibility is *universal moral responsibility*, either direct or indirect. Direct moral responsibility refers to situations where an individual acts in way so as to endanger other beings or their property, such as deliberately setting fire. Indirect moral responsibility refers to acts that indirectly affect others, such as the failure to properly maintain the Koshi barrage, which subsequently led to a major dike rupture and flooding in Nepal and northern India in 2008.

The difference in levels of responsibility between countries evolves with economic development and expectations placed on governments for safety and protection. One example comes from a study of risk perceptions and responsibilities for risk in Valais of the Swiss Alps, suggesting an evolution of responsibility for safety over the past century as society evolved toward an industrialized country (Wiegandt and Lugon, 2007). During this period, social arrangements and institutional constructs evolved from reducing individual/local autonomy and responsibility for risk to more centralized responsibility for risk management. This shift is highlighted by a recent court case condemning a commune in Valais for not preventing several avalanche related deaths (Wiegandt and Lugon, 2007). Responsibility thus shifted from the individual to a collective level in parallel to shifting local perceptions of risk and expectations of government. Today, the Swiss state and insurance companies are expected to provide protection and compensation for any losses due to avalanches, while still being able to maintain the same level of economic activities, notably tourism.

We continue our review of the literature on risk with a discussion on vulnerability and links with risk and resilience.

3.4. Vulnerability

3.4.1. Defining vulnerability

"*…vulnerability is a term of such broad use as to be almost useless for careful description at the present, except as a rhetorical indicator of areas of greatest concern*" Timmermann (1981). Of all elements of the risk equation, the less easily defined factor is vulnerability (Alexander, 2005). We note at least four broad divisions or domains of vulnerability definitions: social sciences; natural sciences and engineering; DRR; CCA definitions. Social science definitions tend to be explanatory and seek to understand root causes of vulnerability. Natural sciences and engineering tend to use the term in a descriptive manner (Füssel, 2007), either to describe future harm, or potential damage (Hinkel, 2011). The DRR and CCA communities use the term in completely different manners, creating confusion and tensions that do not promote closer cooperation between these two closely related groups.

One example of a social sciences definition: ''vulnerability is a characteristic of individuals and groups of people who inhabit a given natural, social and economic space, within which they are differentiated according to their varying position in society into more or less vulnerable individuals and groups. It is a complex characteristic produced by a combination of factors derived especially (but not entirely) from class, gender, or ethnicity'' (Cannon, 1993; Cannon, 2002). According to the author, vulnerability is a characteristic rooted in structural societal, political and economic inequalities. From the natural sciences, a commonly used definition of vulnerability: "is the degree of loss either human or economic", mainly depending on physical characteristics of infrastructure (Fell & Hartford, 1997). This is the definition used for vulnerability to calculate risk, i.e. landslide or flooding risk in a specific locality. To distinguish between the two, the terms "social vulnerability" versus "physical vulnerability" are often used (Birkmann, 2006a; Cutter, 2003). According to Thywissen (2009), social vulnerability to disasters refers to the "*inability of people, organisations and societies to withstand adverse impacts from multiple stressors to which they are exposed. These impacts are due in part to characteristics inherent in social interactions, institutions and systems of cultural values*."

In systems thinking, the vulnerability of a system is multidimensional, or a vector representing state variables, which are dynamic with their own substate variables (Haimes, 2009a). From this perspective, vulnerability is "*the manifestation of the inherent states of the system (e.g., physical, technical, organizational, and cultural) that can be* *subjected to a natural hazard or be exploited to adversely affect (cause harm or damage) that system*" (Haimes, 2009a). In a disaster management context, vulnerability is thus the inherent state of a population, including its level of education, social network, economic system, or access to natural resources Haimes (2009a).

We find here a convergence with UNISDR's 2009b definition as "*the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard*." These characteristics may arise from various physical, social, economic and environmental factors. This definition remains relatively neutral and seemingly an attempt to take into consideration both the social sciences and natural sciences perspectives. It is however criticized for not referring to the past processes, or root causes which led to a certain state of vulnerability (Lewis and Kelman, 2010).

IPCC (2007) defines vulnerability to be "*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*."

This definition, although taking into account longer term processes is focused almost entirely on climate change effects and impacts, which according to this researcher is an incomplete, if not misleading definition of driving forces leading to risk and vulnerability. It also differs by including exposure as part of vulnerability, whereas in the UNISDR 2009b definition, is independent. To sum, the different definitions of vulnerability promoted by UNISDR and IPCC have created confusion, if not tension between the two communities, symptomatic of the inability to promote greater convergence between DRR and CCA. They each promote different definitions of risk. ***As this study is situated within the context of disaster risk reduction, we will refer to the UNISDR 2009b definition of vulnerability.***

Two other themes characterize the vast literature on vulnerability: whether it is a characteristic of a population, or a place; the specific and dynamic nature of vulnerability with regards to a certain threat. The first theme relates to the question whether exposure and vulnerability are interlinked as summarized by the expression 'vulnerability of place' (Birkmann, 2006b; Cutter, 2008a; Lewis and Kelman, 2010; Wisner et al., 2004) described as: "*occupants of places, communities or buildings, knowingly or unknowingly, inherit and become subject to the vulnerability of place. Places have longer existence than people. People come and go, immigrate and emigrate, live and die, in places that have longer histories than those of people's occupancies or people's lives. What is done, or not done, to places by people in distant or recent pasts, can come to affect not only its occupiers at that time, but also those that follow on, recurrently for many years, and in perpetuity*" (Lewis and Kelman, 2010). Certainly, many hazard zones are inhabited by vulnerable people but the 'vulnerability of place' notion supposes that all exposed populations are vulnerable and vice versa. This study maintains that 'vulnerability of place' should remain independent also for the reason that vulnerability and exposure require addressing different factors: the first requires addressing root causes of poverty, the second requires addressing governance, land use planning, zoning and ensuring that people live in safe places.

The second theme relates to the specific and dynamic nature of vulnerability with regards to a certain threat (Birkmann, 2006a; Chambers, 1983; Gaillard et al. 2010; Haimes, 2009a; Wisner et al., 2004). The 2011 Japan catastrophe illustrated that a society may be vulnerable to a tsunami and a nuclear accident, but not an earthquake, for which this society was well prepared. Also, parts of a system may be more or less vulnerable to a threat, i.e. elderly persons in Europe during the 2003 heat wave. Vulnerability is dynamic, evolving over time, depending on each household's economic, demographic or political status and also the frequency of the threat. It is also likely that some subsets of a system may be more strategically valuable, such as the heart for the human system, or the water supply of a village (Haimes, 2009) and to which we may pay more attention. The 2003 heat wave and Hurricane Katrina are unfortunate examples of not paying attention to marginalized, less "strategically valuable" parts of our society.

3.4.2. Vulnerability factors

The literature is rich with discussions about the determining factors of vulnerability.

According to Birkmann (2006), social vulnerability is:

- A dynamic process;
- Rooted in the actions of multiple actions and attributes of human actors;
- Often determined by social networks in social, economic, political, and environmental Interactions;
- Manifested simultaneously on more than one scale;
- Influenced and driven by multiple stresses.

However, we question whether Birkmann's qualification of vulnerability as a dynamic process is accurate as this contrasts with the UNISDR 2009b definition of vulnerability being the characteristics or state of a community (or household), which is subject to various processes (i.e., economic exchanges). As reported in Twigg (2010), who is better known for his 170 characteristics of disaster resilient communities, vulnerability can be characterized by the following indicators:

Vulnerabilities

Thematic Area 1: Governance	• Ethnic, caste and socio-economic divisions in community. • Lack of effective political structures. • Weak government disaster management structures (national & local).
Thematic Area 2: Risk Assessment	• Lack of data. • Lack of any early warning system.
Thematic Area 3: Knowledge and Education	• Fatalism. • Lack of understanding of root causes of disasters. • Different male-female perspectives on hazards and disasters. • Low levels female education. • Lack of educational facilities for girls. • Low levels female hazard knowledge.
Thematic Area 4: Risk Management and Vulnerability Reduction	• High population density. • Very high proportion of population in hilly locations exposed to multiple hazard risks. • High levels of poverty. • Limited livelihood opportunities (dependence on agriculture). • Remoteness; inadequate transport infrastructure. • Difficulty in accessing markets (goods & labour). • Landholding arrangements (high tenancy levels). • Women confined in/ around home. • Inadequate housing (not earthquake-resistant). • Lack of local health facilities. • Lack of power supplies. • Lack of public facilities for community meetings, etc.
Thematic Area 5: Disaster Preparedness and Response	• Lack of any formal CBDM.

Figure 23. Indicators of vulnerability developed by Church World Service, Pakistan (from Twigg, 2010)

Another more quantitative method for assessing vulnerability and capacities is suggested by Moench & Dixit (2007) to respond to policy makers' needs for quantitative data for justifying practical measures. The proposed method has 11 'critical drivers of vulnerability' or indicators in three categories: material, institutional and attitudinal vulnerabilities. If capacity is lacking in these areas, then negative scores were attributed. Weights were assigned based on a study conducted by Vincent (2007).

		vul	cap
	Material Vulnerabilities	**35**	
1	Income Source: If 100% dependent on a local level productive asset, e.g., fishing, land, shop, etc.	10/12	
	- Lower vulnerability score by 1 for every 10% of non-local income reported		
	- Subtract 2 if the income source is stable and insensitive to local hazard.		
	- Add 2 to the score if the income source is unstable, e.g. day labour.		
2	Educational Attainment: If no member of the household is literate	5	
	- Lower vulnerability score by 1 for every 5 years of schooling of the most educated male member of the household.		
	- Lower the score by 2 for every female member's 5 year schooling.		
3	Assets: If none of the assets are immediately fungible, e.g., farm implements, household items	8	
	- Lower the score by 1 for every Rs. 20,000 of fungible assets, e.g. tractor, animals, savings, jewelry (to be calibrated empirically).		
4	Exposure: Distance from the source of prime hazard, e.g., river, coastline, landslide zone. If within the equivalent of 10-yr. flood plain	10	
	- Lower the score by 1 for the equivalent of every 10-yr. flood plain residence and or assets.		
	- Lower the score by 1 for every piece of evidence of hazard proofing, e.g., building of a house on higher plinth for floods, light construction, low cost construction which could be rebuilt with local resources.		
	Institutional Vulnerability	**50**	
5	Social Networks: Membership of ethnic, caste, professional or religious organization or grouping. If none, then	10	
	- Lower vulnerability score by 2 for every instance of past assistance by a group/organization in adversity.		
	- Lower multiple times if multiple organizations.		
	- Lower score by proportion of respondents reporting the organization to be efficacious.		
6	Extra-local kinship ties: If no extra-local kinship or other ties which could be source of shelter and assistance during adversity	5	
	- Lower the score by 2 for every immediate family member living extra-locally		
	- Lower the score by 1 for every non-immediate family member living outside		
7	Infrastructure:		
	Lack of an all-weather road	4	-4
	If seasonal road then		-2
	Lack of electricity	2	-2
	Lack of clean drinking water	2	-2
	Lack of robust telecommunications (mobile coverage)	4	-4
	Lack of local medical facility	4	-4
8	Proportion of dependents in a household:		
	If the proportion is greater than 50%	5	
	- Lower the number by 1 for every additional earning member	or	
	If a single parent headed household	10	
9	Warning Systems:		
	Lack of a warning system	4	-4
		or	or
	Warning system exists but people are not aware of it or don't trust it	4	-4
10	Membership of disadvantaged lower caste, religious or ethnic minority	5	
	Attitudinal Vulnerability	**15**	
11	Sense of Empowerment:		
	Self declared community leadership		-10
	or		or
	Proximity to community leadership		-10
	Proximity to regional leadership structure		-15
	or		or
	Access to national leadership structure		-15
	Lack of access to community or regional leadership	10	
	Lack of knowledge about potential hazards (lower score by 1 for every type of hazard and its intensity accurately listed by respondents)	5	
	Total Possible Vulnerability Score	**100**	

Figure 24. Vulnerability and Capacity Index, (from Moench & Dixit, 2007)

Füssel (2007) has developed a useful framework for presenting different categories of vulnerability factors according to what he calls the socio-economic and biophysical domains as compared to internal and external spheres (Table 13).

Sphere	Domain	
	Socioeconomic	**Biophysical**
Internal	Household income Social networks Access to information Construction norms	Topography Environmental conditions Land cover
External	National policies International aid Economic globalization	Severe storms Landslides Earthquakes Sea level change

Table 13. Examples of vulnerability factors classified according to spheres and domains (modified from Füssel, 2007)

The internal sphere relates to community/household abilities to change and cope, external refer to domains outside the community/household sphere of influence. What is interesting about this framework is that it describes different scales of factors that create vulnerability, from national policies, international aid and market forces which have impacted the household level, where poor access to resources has created local socio-economic and bio-physical vulnerability. On the biophysical side, hazards are presented at the larger scale, over which we have little control in contrast to biophysical conditions at the local scale. This framework thus suggests that in order to tackle vulnerability, all levels of factors need to be addressed, an important issue when we discuss capacity building of local populations through development and DRR interventions. We can use the table to consider the various roles of NGOs and international organizations. The scope of action of NGOs is mainly at the local, or internal level, while for international and national organizations it is at the external level. What we are observing with the vast international campaign on CCA and resilience is that the focus is internal, to the detriment of the external factors causing vulnerability (to be developed in section 3.5). Various adaptation funds have been established with millions of dollars made available for local projects for adapting to changing climate conditions but not for addressing the structural social, political and governance issues (external domain) that are creating vulnerability.

3.4.3. Vulnerabilities and capacities

Capacities are the combination of the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals or the resources (cultural, social, economic and political) available to households and communities to address threats and their impacts on livelihoods (UNISDR, 2009a). Capacities are therefore based on endogenous skills and knowledge, whereas vulnerability mainly results from exogenous factors leading to unequal entitlements and access, consistent with Table 13 (Füssel & Klein, 2006; Gaillard et al. 2010). After decades of depicting vulnerable populations as victims of calamities and poverty, numerous academics and NGOs have instead highlighted the latent capacities of people to overcome adversity if given the means and opportunity to participate (Heijmans & Victoria, 2001; Anderson and Woodrow, 1998). This more positive focus on 'capacity building' rather than reducing vulnerability resonates with policy makers and donors, also providing the foundation for the 2005 UNISDR policy document: "Hyogo Framework for Action", where capacity building of local communities is a cornerstone (Gaillard et al. 2010). This focus on capacity building runs in parallel with "building resilience", the latest international buzz word, to be developed in section 3.6. One example of capacity indicators (Figure 25) is reported in Twigg (2010).

Capacities

Thematic Area 1: Governance	• Community self-reliance and solidarity in crisis. • Political representation of poor/marginalized groups. • Custom of landlords providing help in crisis. • External involvement in development projects.
Thematic Area 2: Risk Assessment	• Community identification of landslide-prone locations.
Thematic Area 3: Knowledge and Education	• Community memory of past events. • High levels community awareness of hazards and risks. • High levels access to mobile phones and radios. • Community demand for girls' school.
Thematic Area 4: Risk Management and Vulnerability Reduction	• External involvement in development projects (sustainable livelihoods). • Remittances from migrant workers. • Surplus of livestock products. • Honey production.
Thematic Area 5: Disaster Preparedness and Response	• Community self-reliance in DP and response.

Figure 25. Indicators of capacity developed by Church World Service, Pakistan (from Twigg, 2010)

As a result, a variation of the risk equation is commonly found in the NGO literature, where vulnerability is given as a qualitative measure and divided by capacities, in line with the notion that increasing capacities reduce vulnerability (IFRC, 2007; Practical Action, 2010).

$$R = H * Exp * [V/C]$$

However, this equation is frequently criticized as the relation between capacities, and vulnerability is not necessarily directly opposite. With reference to Table 13, it may be an illusionary to believe that increasing local capacities would suffice in order to reduce vulnerability, or risk for that matter. Rather structural measures such as economic and political reform and improved governance are required at the national level, independent of what is possible for populations to achieve at the local level (Wisner, 2003). As discussed in the introduction, this critique is the same for the recent focus on resilience.

3.4.4. Assessing vulnerability

Measuring vulnerability is a subject of great interest by policy makers and NGOs in order to assess the effectiveness of decades of investments in vulnerability reducing measures. However, there is no universal measure of vulnerability and there are as many ways of assessing it as there are vulnerability researchers. It is most commonly used to calculate physical vulnerability quantitatively as part of the risk equation as degree of loss times exposure, i.e. percent of houses destroyed by a landslide times the amount of time household members spend in their house. However, there is a need to develop composite indicators of vulnerability that take into account the multiple facets of vulnerability: natural, social, economic, human/institutional as well as physical. There are only a handful such composite indicators for assessing vulnerability and risk. Examples are (Bollin and Hidajat, 2006), who developed a community based composite indicator of risk for volcano affected populations in Indonesia; and Damm (2009) who developed a composite vulnerability indicator for flood affected regions of Germany. There are no known vulnerability assessment methodologies for landslide affected populations at the community level.

The importance of assessing vulnerability is well articulated by Birkmann and Wisner (2006), "*If the aim of common efforts in disaster risk reduction is human security and sustainable human development, then wisdom would result from the critical assessment of outcomes when one tries to implement policy at international, national, or local scale or when people in a locality attempt to act on behalf of their own to improve self-protection*." This policy need has driven a number of academic and NGO-based initiatives. For example, UN University's Environment and Human Security Institute reunites experts worldwide for annual workshops to address this issue, resulting in several influential publications: "Measuring the Un-Measurable, the Challenge of Vulnerability" (Birkmann & Wisner, 2006).

Methods for assessing vulnerability will depend on the objectives and scale of the population, system or assets to be studied.

Examples of methods for assessing vulnerability (Birkmann, 2006a):

1) Assessment of the built environment using remote sensing ;
2) Critical infrastructure and sector vulnerability using ground surveys of basic infrastructure services and their facilities, e.g. hospitals and schools;
3) Vulnerability of social groups and local communities using questionnaire-based interviews with households in selected locations to identify and assess the different vulnerabilities of various social groups. Focus group discussions, in-depth interviews with selected families and key informant interviews, census data-based assessment of vulnerability using general indicators:
4) Vulnerability and Capacity Assessment (VCA) methodology was developed by academics (Anderson and Woodrow, 1999) and applied widely by many NGOs, notably the International Federation of Red Cross and Red Crescent Societies (IFRC, 2007) as a scoping tool to evaluate where to concentrate relief efforts. The VCA uses mainly largely qualitative indicators and a grid crossing three main factors physical/material; social/organizational; and motivational/attitudinal with vulnerabilities and capacities. The process is highly participatory, using data collection techniques developed by Rapid Rural Appraisal methods (i.e. participatory risk and social mapping, transect walks, seasonal calendars).

Whether data and information are collected at the local level or for national and international assessments, one may be required to take one to step back from such rich detail and to simplify in order to better communicate research findings with non-experts. For this, one needs indicators or more distant proxies, either narrative, qualitative or quantitative (Birkmann and Wisner, 2006). However, there is an increasing body of literature criticizing vulnerability indicators for not being scientifically sound, or policy relevant, "*a typical example of failed science-policy communication*" (Hinkel, 2011, quoting Eriksen and Kelly, 2006; Klein, 2003). It is true that indicators, like models simplify reality at the risk of oversimplification or being "unscientific". However, Hinkel (2011) continues by stating that "*indicators constitute one approach to making theoretical concepts operational*".

There are different types of indicators, which can be developed either using inductive methods, based on observation, or deductive methods, based on theory:

- scalar indicators (or proxy indicators) map one observable variable to explain another (e.g. low education is one variable explaining poverty);
- composite indicators (or indexes) aggregate several observable variables to one scalar theoretical variable (e.g. Human Development Index);
- vector-valued indicator, which are usually represented as diagrams with interactions between three or more variables on an axis starting from a central point (e.g. Water Poverty Index).

(Hinkel, 2011)

3.4.5. Vulnerability models

The most common models in vulnerability studies are the Pressure and Release (PAR) model (Blaikie et al., 1994; Wisner et al. 2004), and Access model (Cannon et al., 2003; Wisner et al., 2004), both illustrating links between vulnerability, livelihoods and capacities to adapt, cope with and recover to stress and shocks. The PAR model (

Figure **26**) highlights cumulative processes: root causes, dynamic pressures and unsafe conditions creating vulnerability on one side, with physical exposure to hazards on the other. Pressure can only be released if vulnerabilities decrease, by addressing root causes through improved access to power and resources, reducing pressures by developing capacities such as skills and market access, stabilizing demographic and environmental degradation, improving environmental and living conditions, including diversified and strong livelihoods. The Access Model builds on the sustainable livelihoods approach (Section 3.5.9) to more fully integrate how social systems create vulnerability to hazard events through various levels of social protection, governance, environmental management, and access to resources, including power.

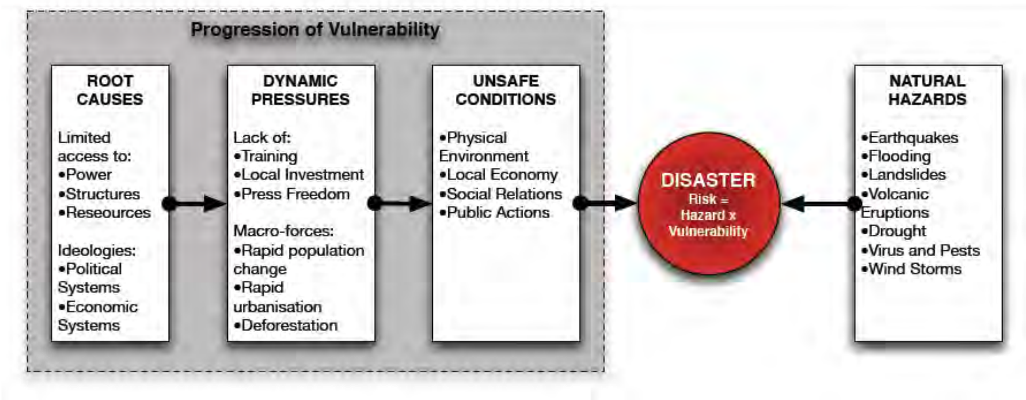


Figure 26. Pressure and release model, (from Wisner et al., 2004).

The PAR describes root causes of vulnerability and poverty mainly linked to factors exogenous to households. These are economic, demographic and political processes, translated into limited access to resources, markets, institutions and power. Root causes need to be understood in their historical contexts, oftentimes based on colonial heritage and geopolitics (Bankoff, 2001; Lewis, 1999). Cultural biases, such as gender imbalances or caste systems, access to land ownership, or ideologies favoring political allegiance are also root causes of vulnerability. Dysfunctional governance systems and root causes form a negative feedback spiral, sometimes fueled by the international financial and political system, corruption, and inadequate checks and balances. We also distinguish between factors of vulnerability that are mainly created by a poor enabling environment, and specific household circumstances, such as family illness, female headed households, recent migration or social exclusion that may increase a family's vulnerability. Both models are tools for explaining vulnerability, not for measuring it. They cannot be applied operationally without a great deal of data collection and analysis.

Two other models, the Turner et al. (2003) and BBC (Bogardi, Birkmann and Cardona, 2006) models have influenced the vulnerability literature (Figure 27). Following the IPCC definition of vulnerability, the Turner et al. model (2003) illustrates the multiple drivers and "coupled human-environmental conditions" that affect vulnerability at multiple scales. It thus includes exposure, sensitivity and resilience as part of vulnerability. As such, the model remains quite complex and difficult to operationalize.

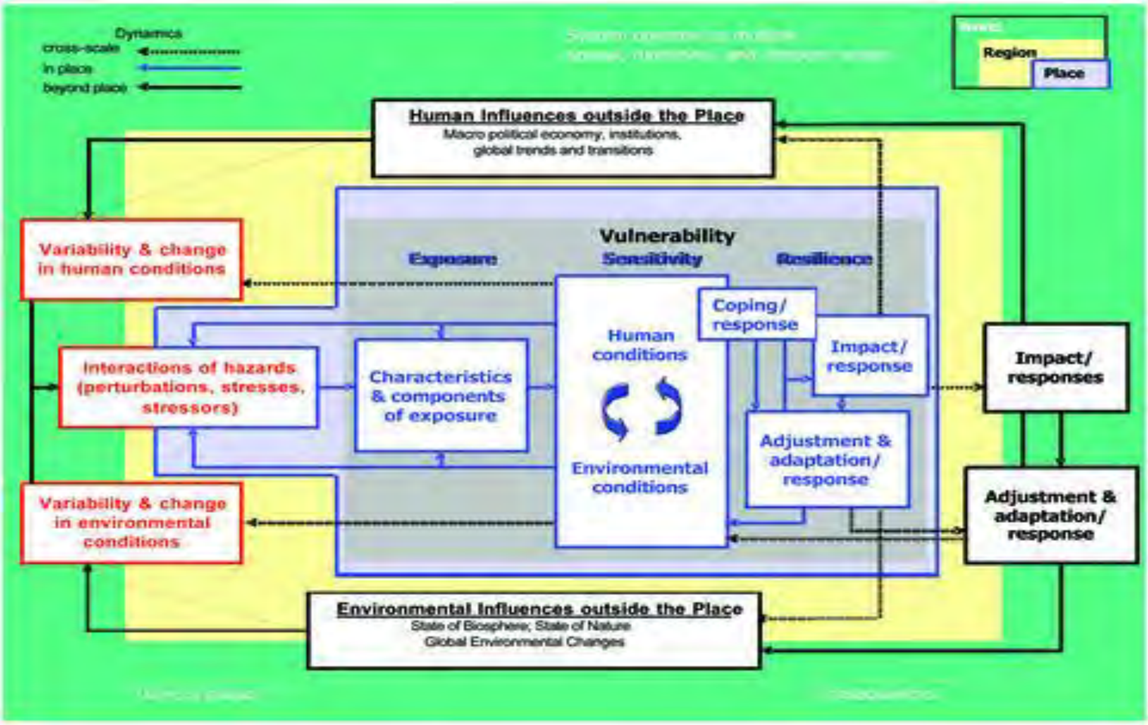


Figure 27. Turner model of vulnerability (from Turner, 2003)

The BBC model (Birkmann, 2006a) goes a step further by illustrating the relation between vulnerability, hazard, risk and risk management, dividing risk and vulnerability into various spheres, environmental, social and economic (Figure 28). It is also useful by illustrating feedback loops and possible ways to mitigate risk. However, here again, exposure and coping capacities are included as part of vulnerability, and making this model also difficult to operationalize.

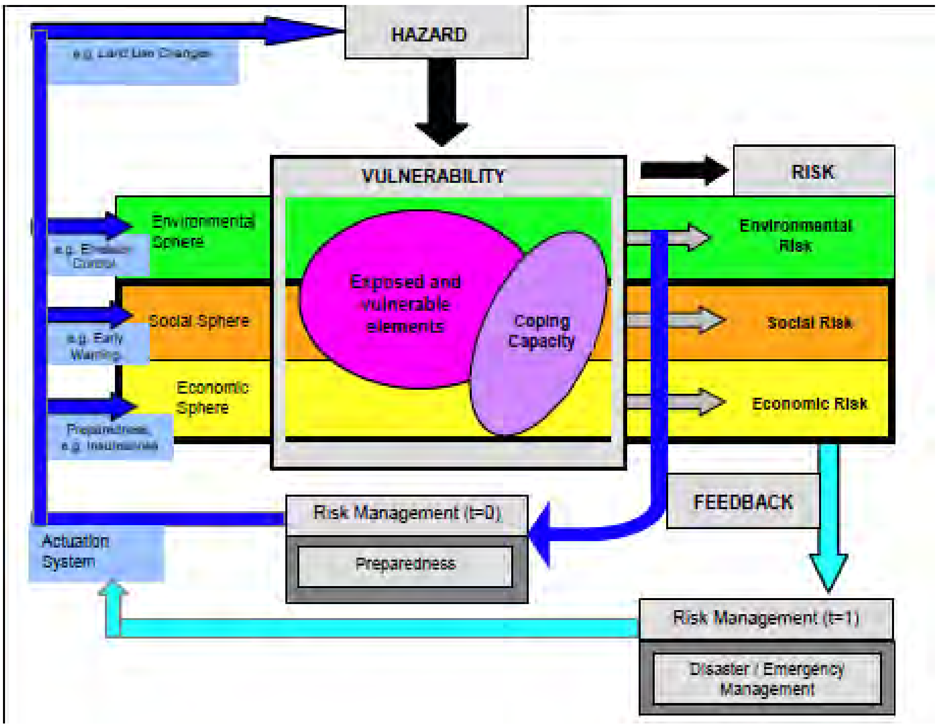


Figure 28. BBC model of vulnerability Bogardi, Birkmann and Cardona, (from Birkmann, 2006)

Models on vulnerability as defined by IPCC can be significantly different, as we noted in the section on definitions. Here is one example given by Füssel and Klein (2006), where vulnerability is considered the outcome of exposure, sensitivity and impacts, basically corresponding to the UNISDR (2009b) definition of risk. As stated above, these two very different visions of vulnerability and risk are creating confusion and communications difficulties between the two research and practitioner communities.

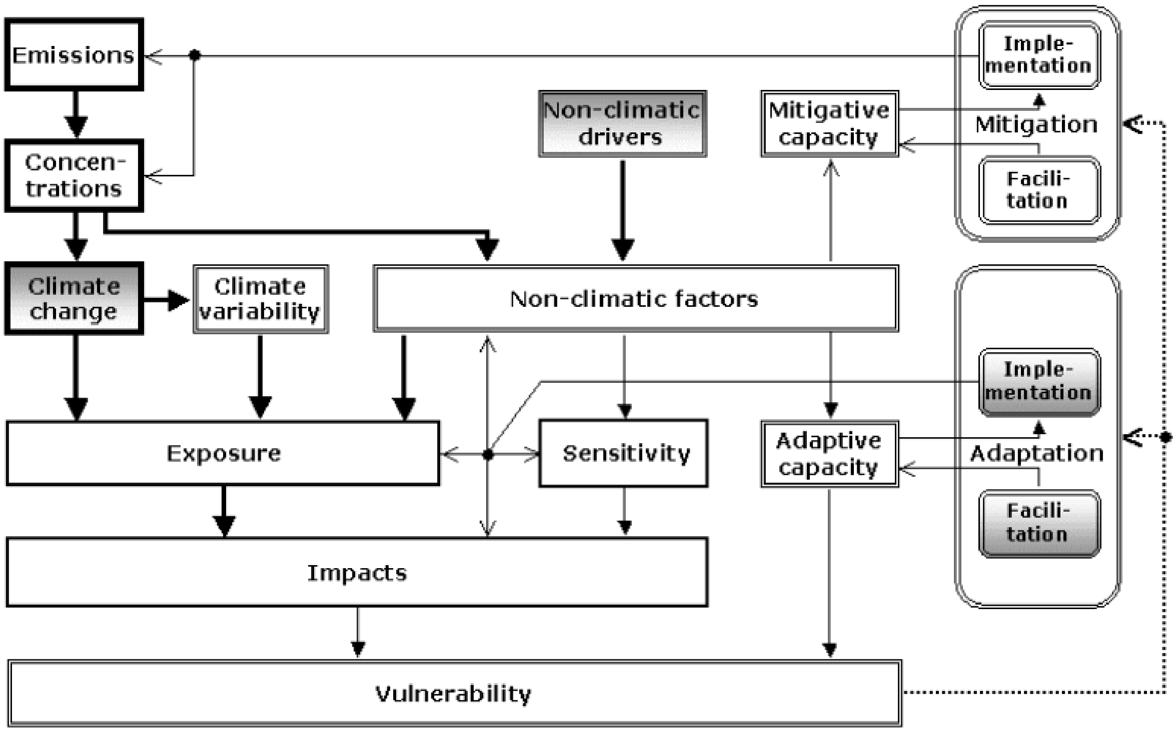


Figure 29. Relationship between key terms employed in climate change adaptation assessments (from Füssel and Klein, 2006).

3.4.6. Concepts of vulnerability

To summarize this section on vulnerability, it may be helpful to schematize the different approaches and definitions of vulnerability used by the DRR and CCA communities. As mentioned above, there are many different ways of classifying vulnerability and a plethora of authors who have written on the topic. We are mainly concerned with having a clear idea of main reoccurring concepts related to vulnerability. These are summarized in Table 14.

Disaster risk reduction	Social vulnerability : a dynamic process	Vulnerability is an internal capacity to anticipate and address adversity.	Theory of social construction and social protection. Access Model BBC Model	Cannon (2007) Birkmann (2006a)
	Vulnerability of place	Vulnerability is linked to a specific place and imbedded with exposure.	Theory of vulnerability of place. DROP model	Cutter et al. (2008a)
	Vulnerability as a state	Vulnerability as a state or set of characteristics of a person or population due to poor access to resources.	Theory of access & rights. PAR model	Blaikie et al (1994) Sen (1999) Wilches Chaux (1993) Wisner et al. (2004)
Climate change adaptation	Social science interpretation	Susceptibility to climate change and variability as determined by socioeconomic factors.	Vulnerability results from sensitivity and exposure. Vulnerability determines adaptive capacity. IPCC model. Turner et al. model	Adger (2006) Turner et al. (2003)
	Natural science interpretation	Expected net damage for a given level of global climate change.	Adaptive capacity determines vulnerability.	McCarthy et al. (2001)
Integration of DRR and CCA	Combines social and natural sciences	External' and an 'internal' side of vulnerability to environmental hazards	Theory of internal/external domains and spheres	Füssel (2007)

Table 14. Summary of main concepts related to vulnerability, definitions and theories as defined by DRR and CCA scientists.

3.5. Resilience

If resilience is the solution, then what is the problem, really?

"*After thirty years of academic analysis and debate, the definition of resilience has become so broad as to render it almost meaningless*" (Klein et al., 2003).

3.5.1.Resilience, the new paradigm of development, climate change and disaster risk reduction

Use of the term "resilience" has increased exponentially over the past decade with the increased focus on climate change and DRR (Figure 30). We observe new terms such as "climate resilient development", "disaster resiliency", "resilience management", "resilience manager". It is now considered by many proponents to be a binding force linking development, CCA and DRR (Bahadur et al. 2010). Resilience is also the goal of the Pilot Programme for Climate Resilience, a multi-million fund established by the Climate Investment Fund, established in 2008 by several International Development Banks (Ayers, Kaur, & Anderson, 2011).

The attractiveness of resilience lies in its more positive focus on local capacities than the negative connotation attributed to vulnerability. Despite its increased popularity for international policy there is limited theoretical understanding and multiple, often contradictory definitions of "resilience" (Manyena, 2006). Thus resilience has become the new goal of disaster risk reduction and climate change adaptation of international and national policies, without the means to track whether resilience is increasing or decreasing and without adequate definitions. A prime example is UNISDR's the mission statement "to build the resilience of nations and communities to disasters" and the Hyogo Framework for Action 2005-2015 (HFA), with 168 signatories. The framework has developed a number of priorities for action, and key activities that seek to build resilience to disasters across multiple scales. Another example is a recent headline: 'UNICEF launches USD 1.4 billion appeal, calling for building the resilience of communities' (March 7, 2011, www.preventionweb.org). The UNISDR mission statement and UNICEF headline are eye-grabbing and problematic. Cannon and Müller-Mahn (2010) even describe this development as "dangerous" because resilience and CCA are distracting attention from the real issue: underlying causes of risk and vulnerability are rooted in uneven power relations, market inequalities and poor governance.

Figure 30. Occurrence of the term resilience as measured by news releases by Agence France Press 1985-2008, (from Damon, 2009)

There is an even less practical applicability of the term and the multitude of definitions makes it difficult to establish an operational framework. Due to the complexity of the concept, a main challenge is determining which indicators should be used, and how to measure them in order to inform disaster risk reduction policies (Cutter et al. 2008b; Mayunga, 2007; Rose, 2007). As resilience has now been elevated to a policy level with millions of dollars already being invested by donors into building "climate resiliency", the expectation is that there be project deliverables and results. The difficulty in discussing, describing and operationalizing resilience is the same as for vulnerability: it has different meanings and is expected to accomplish many different policy objectives for which it was not really intended. There is little guidance or benchmarks that describe what resilience is, how to increase it, or when it has been achieved. The same can be said for the numerous NGO projects that have been established to increase community resilience. Even though a number of academic groups and NGOs are seeking ways to operationalize resilience (Cutter et al. 2008b; Cutter et al., 2010; Paton & Johnston, 2001; Twigg, 2010), there have been few studies that propose indicators or metrics of resilience. To sum, resilience has today virtually replaced the term "sustainable development" as a main international policy goal, with the expectation that it will solve all problems, a "magic bullet" and "catch all". It raises a number of questions: Resilience to what (Klein, 2003)? How to increase it? What is a disaster resilient community? (Twigg, 2010) What problem does it seek to solve (Nelson, 2010)?

This thesis was developed and funded to analyze the concept of resilience that dominates current international development, climate change adaptation and DRR policies, projects and funding schemes. We begin this section with a brief overview of the genesis of the concept and some definitions before discussing various approaches and models of resilience.

3.5.2. Defining resilience

Resilience has its roots in the latin, *"resiliere",* to bounce back after a shock and has been extensively used in the literature especially in ecology, child psychology, engineering and economics. In 1807 Thomas Young, an English physicist was probably the first scientist to use the term to describe the capacity of material *to absorb energy without suffering permanent deformation* (Yunes (2003) as described by Amorim (2009)).

In systems sciences, resilience is: " *the ability of a system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable time and composite costs and risks*" (Haimes, 2009b). According to systems thinking, other characteristics of resilience include *robustness,* which refers to the degree of insensitivity of a system to perturbations and *redundancy*, which refers to the ability of certain components of a system to assume the functions of failed components without adversely affecting the performance of the system itself (Haimes, 2009b).

In building engineering, seismic resilience of buildings is part of a system which has:
1. Reduced failure probabilities;
2. Reduced consequences from failures in terms of lives lost, damage, and negative economic and social consequences;
3. Reduced time to recovery' (Bruneau and Reinhorn 2006, as quoted by Bahadur et al. 2010).

Tierney and Bruneau use the "R4 Framework" , which describes resilience as:

- Robustness – the ability of systems and other units of analysis to withstand disaster forces without significant degradation or loss of performance;
- Redundancy – the extent to which systems or other units are substitutable if significant degradation or loss of functionality occurs;
- Resourcefulness – the ability to diagnose and prioritize problems and initiate solutions by mobilizing material: monetary, informational, technological and human resources;
- Rapidity – the capacity to restore functionality in a timely way, containing losses and avoiding disruptions.

(modified from Tierney and Bruneau, 2007)

In economics, resilience refers to "*the inherent ability and adaptive responses of systems that enable them to avoid potential losses*" (Rose, 2005).

In child psychology, resilience refers to "*the process of, capacity for, or positive outcome of successful adaptation despite challenging or threatening circumstances*" or "good outcomes in spite of serious threats to [child] development" (Masten, 1994; 1999; Norris, 2008). Masten (2011) however cautions about being overzealous with regards to resilience and cites the " Three Dangers of Resilience Models" Danger 1: "Don't worry, children are resilient"; Danger 2: Resilience as a The magic bullet; Danger 3: Ignoring preventable risks" (Masten, 2011).

A Short List of Protective Factors Suggested by Research on Resilience in Children

Ordinary parents
Connections to other competent and caring adults
Good intellectual skills
Self-efficacy
Talents valued by society and self
A sense of meaning in life
Faith and religious affiliations
Socioeconomic advantages
Good schools
Community resources

(Masten, 2011)

Textbox 2

Also see textbox 2 "A Short List of Protective Factors Suggested by Research on Resilience in Children".

French child psychologist Boris Cyrulnik studied traumatized children during the Second World War having survived concentration camps, himself a concentration camp survivor. He described those who succeeded, a majority but not all, as spring boards with above average achievement, given the means and encouragement (Cyrulnik, 1999). The disturbance provided an opportunity to bounce back beyond the initial state. These children became resilient only after having experienced a traumatic event but were still subject to higher than average rates of depression. Thus both child psychologists Cyrulnik and Masten describe resilience as a desired quality to overcome stress or disturbance, but not synonymous to happiness or "a magic-bullet".

Resilience was not invented (as many claim) but made more popular by ecological studies as it relates to natural disturbance of ecosystems. Resilience is considered as the ability of a system to adapt to and either maintain its pre-disturbance equilibrium or its ability to transform to a different state as a consequence of stress or shock, or "adaptive capacity" (Holling et al. 1973; Folke, 2006). A ready example is a forest after a forest fire, which depending on the intensity of the fire and the pre-fire state of the forest, may return to its pre-fire state or move on to a new equilibrium, with a new forest composition.

UNISDR defines resilience as: "*The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions*." UNISDR provides this adjoining comment: "Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need (UNISDR, 2009b)." IPCC's (2007) definition of resilience is to "*absorb disturbances while retaining the same basic structure and ways of functioning*".

The above definitions vary considerably in several regards: whether the concept resistance should be included in resilience alongside recovery, the timescale considered, (i.e. chronic stress over a long period or acute, discontinuous stress and short term) as well as the relation of resilience to vulnerability. Timmermann's (1981) pioneering work on adaptation, vulnerability and resilience was one of the first to address such issues in the context of climate change, defining resilience, as 'elasticity', or "*the measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event*" (p.21).

Within the hazards and vulnerability literature there are three broad definitions of resilience: those who believe that resilience and vulnerability are on opposite ends of the same spectrum (Adger et al. 2005; Cannon, 2007; Birkmann 2006a; Bahadur et al. 2010); those who consider vulnerability as separate, possibly overlapping but not its opposite (Turner et al., 2010; Buckle et al., 2001; Timmermann, 1981; Gallopin, 2006); and others who believe they overlap to some extent (Cutter, 2008b). According to Gallopin (2006), "vulnerability refers to the capacity to preserve the structure of a system, while resilience refers to its capacity to recover from non-structural changes". In other words, vulnerability is a baseline of sorts, while resilience indicates the ability of the system to fluctuate, while returning to its baseline. On the other hand, robustness, a measure of strength, may be thought of as the flip side of vulnerability (Gallopin, 2006).

Other difficulties of these resilience definitions are certain normative terms such as the resilience of a system to recover within "acceptable time". Acceptability is contextual and will obviously vary considerably between populations and notions of efficacy. Other attributes of these definitions include the notion that resilience of a system can only be measured in terms of a specific threat (input), the system's recovery time and the associated costs and risks (Haimes, 2009). Thus a mountain population in Nepal may be resilient to an outbreak of cholera as certain measures of hygiene and water purification have been put in place, with few resulting casualties - whereas the same population is not resilient to landslides, which may affect the population during each monsoon period. To sum, the term resilience varies depending on the discipline or sub-discipline defining it, with at least one commonality: it refers to the capacity of a system to recover following stress, whether chronic or acute. This study definesresilience as: ***the ability of a***

system, community or household to change in a positive manner, faced with adversity. The alternative: negative change characterizes dysfunction, weakness, vulnerability.

3.5.3. Resilience models

In this section, we review some models illustrating resilience and others that illustrate the relation between resilience, risk and vulnerability. The Adaptive Cycle (Figure 30) describes resilience as a dynamic process, with the example of an ecosystem from its growth phase (e.g. a forest following a fire) to a more mature conservation phase (e.g. a mature forest), followed by a disturbance, or release phase (e.g. forest fire), renewal and re-organisation into a new level of resilience, or "panarchy" (Gunderson et al., 1995)

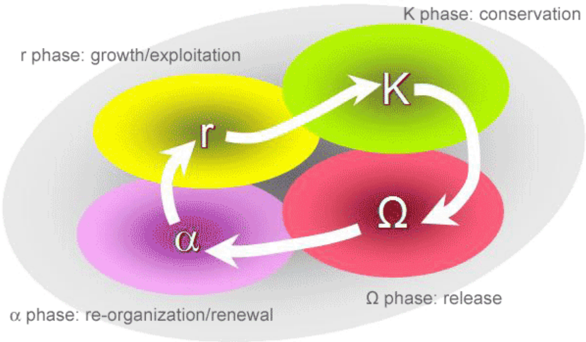


Figure 30. Adaptive cycle, (from the Resilience Alliance, 2011)

In this model, disturbance is an integral, even desired part of a resilient ecosystem, allowing to renew the system and increase its resilience, or "disturbance as opportunity" (Folke, 2006). Other characteristics of a resilient ecosystem is a diversification of species (biodiversity) e.g. an agroecosystem, will be more resilient to disturbances than monoculture (Tilman and Downing, 1994; Pimm, 1984; Dorren *et al*. 2004). The concept of resilience is included in the concept of ecological integrity, commonly used as a measure of an ecosystem's health, defined as a system's capacity to maintain structure and ecosystem functions using processes and elements characteristic for its ecoregion (Dorren, *et al.* 2004). Where the theory of the "adaptive cycle" becomes more ambiguous is when it is applied to so-called "coupled socio-ecological systems" to emphasize the interconnected-ness between the two. In human systems, disturbance may bring positive outcomes and move the system toward improved resilience but disturbance, e.g. disasters or financial crisis, are not a desirable feature, as they usually induce high societal costs. Thus even if a useful notion for ecological systems, resilience as described by the "Adaptive cycle" is less so for human systems, whether coupled or not.

Mayunga (2007) illustrates resilience as a hypothetical scenario between two different more or less resilient communities from the pre-disaster to the recovery post-disaster phases (Figure 31).

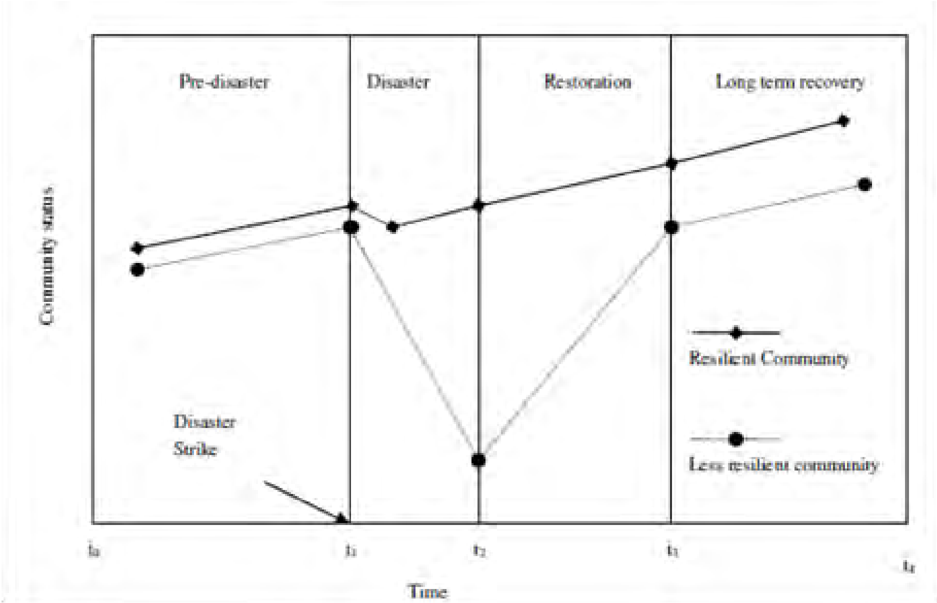


Figure 31. Resilience over time (from Mayunga, 2007)

Figure 32. illustrates a simplified linear disaster management process over time, with hypothetical costs of measures to reduce risk. Costs to reduce vulnerability before and after a disaster are expected to be the highest, followed by capacity building, and other prevention measures. This "costing out" of different types of interventions gives us one answer for why resilience-building has become more popular than vulnerability reduction.

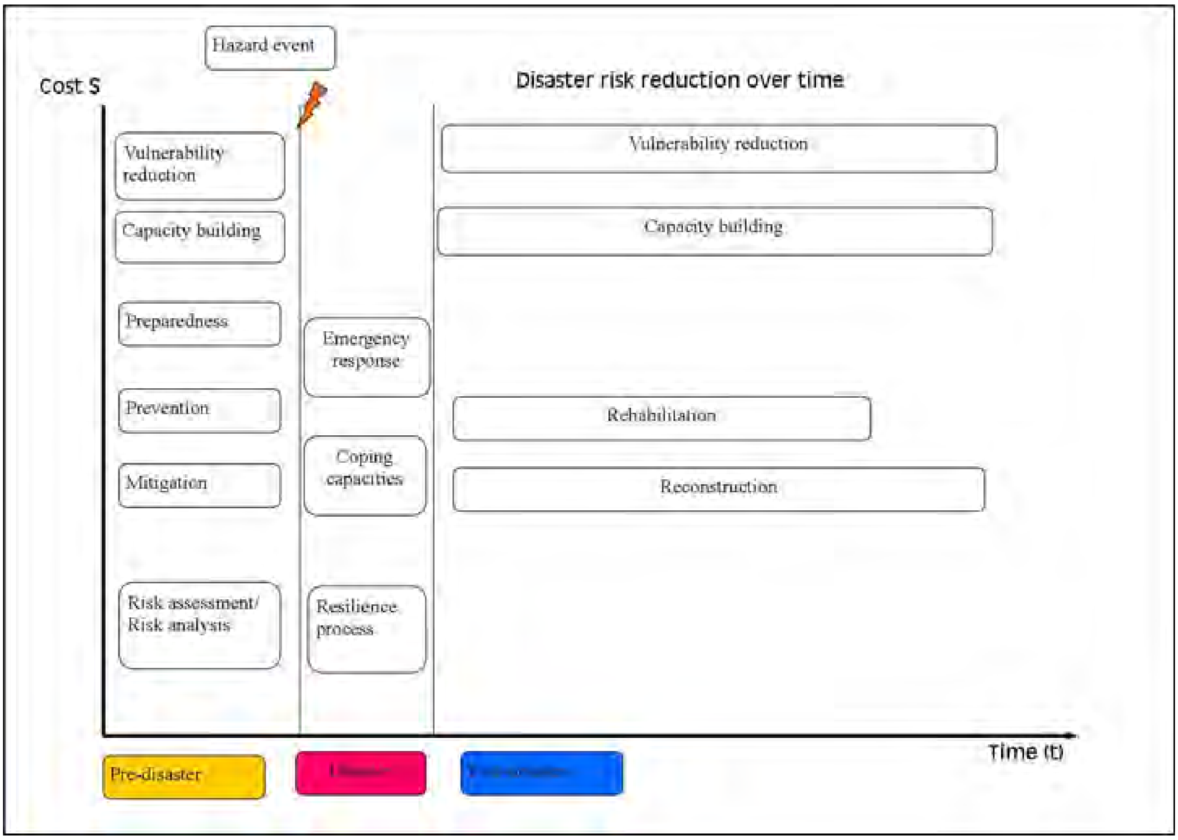


Figure 32. Placing resilience in disaster risk management and hypothetical costs

In Figure 33, the point of departure is point "V", or the degraded state of a household, community or society at the time of a hazard event. Line 0 is the inherent, or "reference" state of a society or system prior to a hazard event. This line can be considered the inherent state, or level of vulnerability of the system. "R1,","R2,", "R3," are considered the levels of risk that the system actually experienced as a consequence of the hazard event. These levels of risk may increase or decrease over time, depending on factors such as exposure to a hazard, vulnerability of a population or its economic status. However, the level of risk is not a function of resilience, or the period of time and resources to recover to the pre-disaster state. Resilience should be considered as a separate process, or parallel to risk and as stated above, may or may not impact vulnerability. It is a reflection on the state of a system and the amount of time required to return to the inherent state. The blue line (+1) corresponds to a system with high resilience, as it surpasses its inherent state, while the red line (-1) corresponds to negative resilience. The curve of these lines will be determined by the specific threat, or hazard event as well as the coping capacity of the system to return to its normal state.

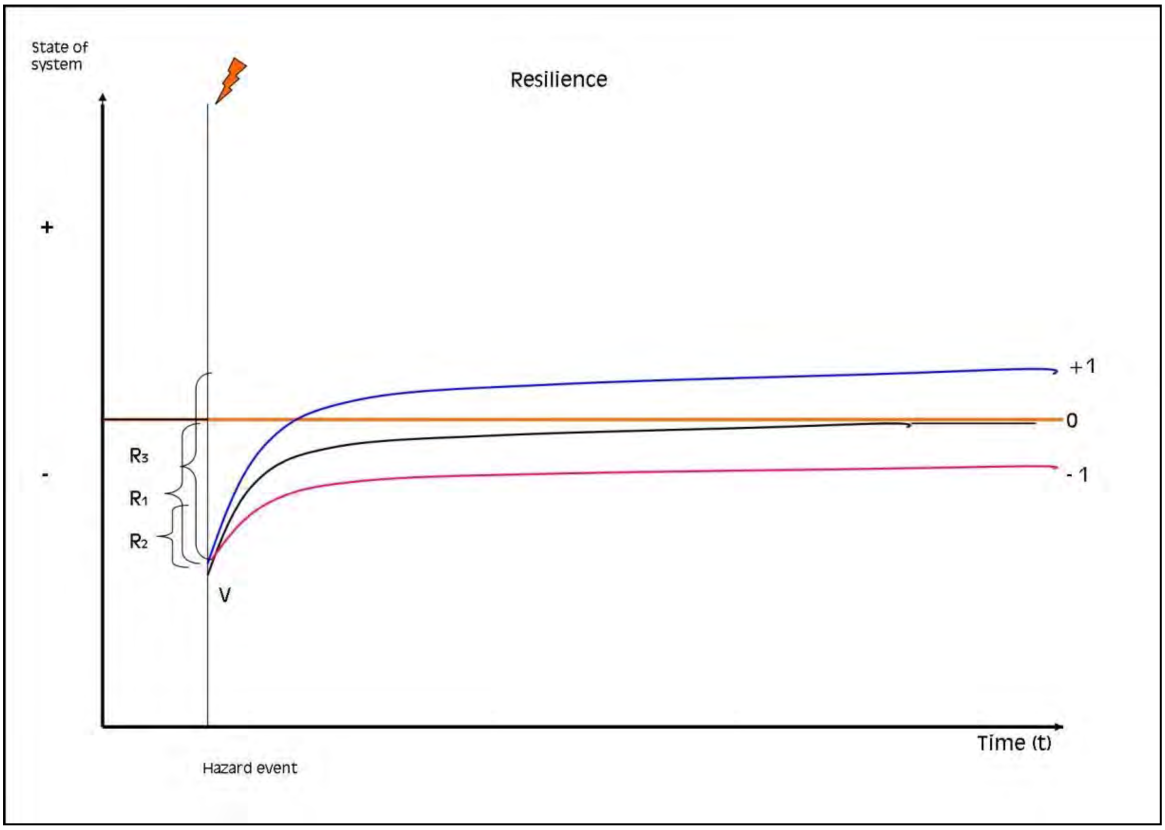


Figure 33. Relation between risk, resilience and vulnerability

In Figure 34, resilience is represented as a function of the hypothetical investments required in cost and time to return to the pre-hazard state. The multiple lines correspond to hypothetical composite costs, e.g. social costs, psychological costs, environmental costs, physical costs, which may be extremely variable and independent of one another. For example, there could potentially be a high physical cost to rebuilding a community following an earthquake (top black line), however it is possible that as a result, the community acquires a social benefit, or positive costs (bottom purple line) through improved communication and coordination.

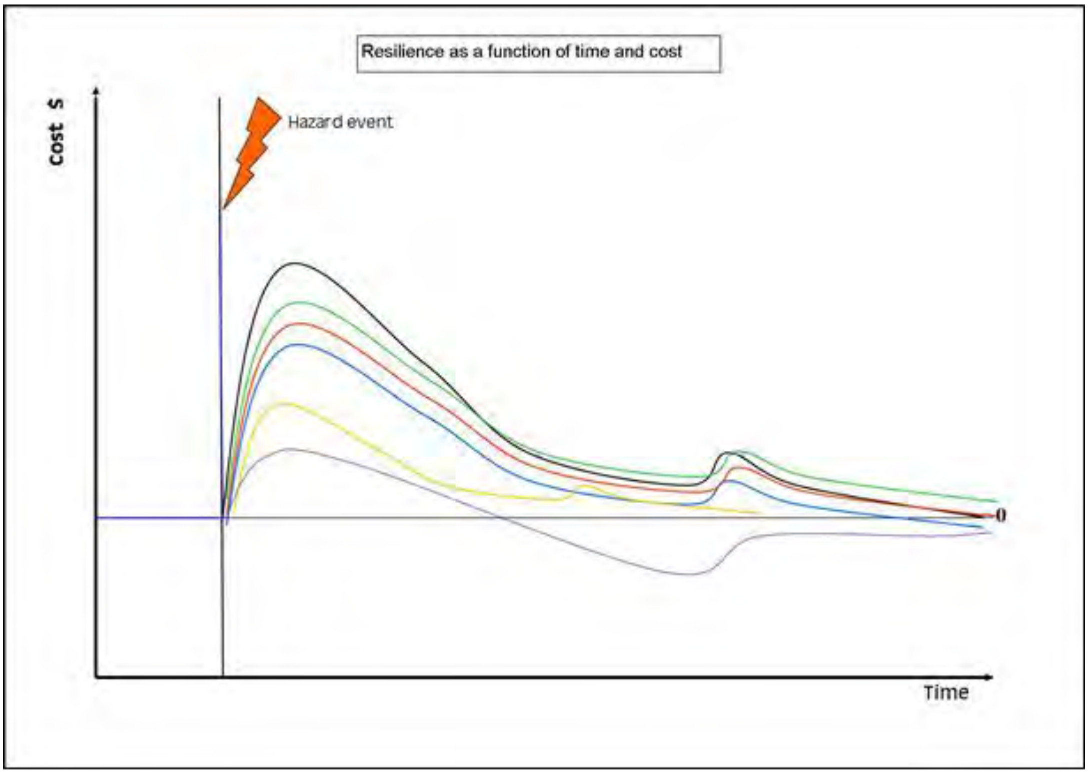


Figure 34. Resilience in terms of time and costs for recovery

Jaboyedoff (2010) considers that resilience is useful as a term to describe and quantify the recovery period, often omitted in risk calculations, which normally only take into account the calamitous event but are an important cost to society (Figure 35). Under such conditions, the total cost (TC) of a catastrophe must be evaluated by:

$$TCi = Ri + PCTi$$

Where R represents Risk of a catastrophe and PCT post catastrophe costs. Resilience can be then introduced as the quantification of the disruption to a society and its evolution over time quantified by the costs of reconstruction plus the change in incomes over the normal incomes per unit of time of a group (or the number of persons restarting or continuing or staring activities in the society over the number of persons normally active before the catastrophe per unit of time) during the post-catastrophe time (ts). This corresponds to the period of recovery before the society again reaches a steady state (fixed state or constant evolution trend).

This can be defined as follows, using the incremental resilience (r(t)): $r(t) = \frac{C(t)Inc(t)}{NI(t)}$

In term of costs, for simplification we can assume that for all (t), we have: $NI(t) = NI$

Thus the resilience Re(ts) for the entire period of recovery is given by: $\mathrm{Re}(t_s) = \int_{t_0}^{t_s} r(t)dt$

This means that:

$$PCT_i = Re(t_s) \times NI$$

These relations give a framework of reasoning because it is clear that the costs must be dependent on time, i.e. especially seasonal, in particular in developing country, because of the harvest periods, also implying a seasonally dependent risk analysis.

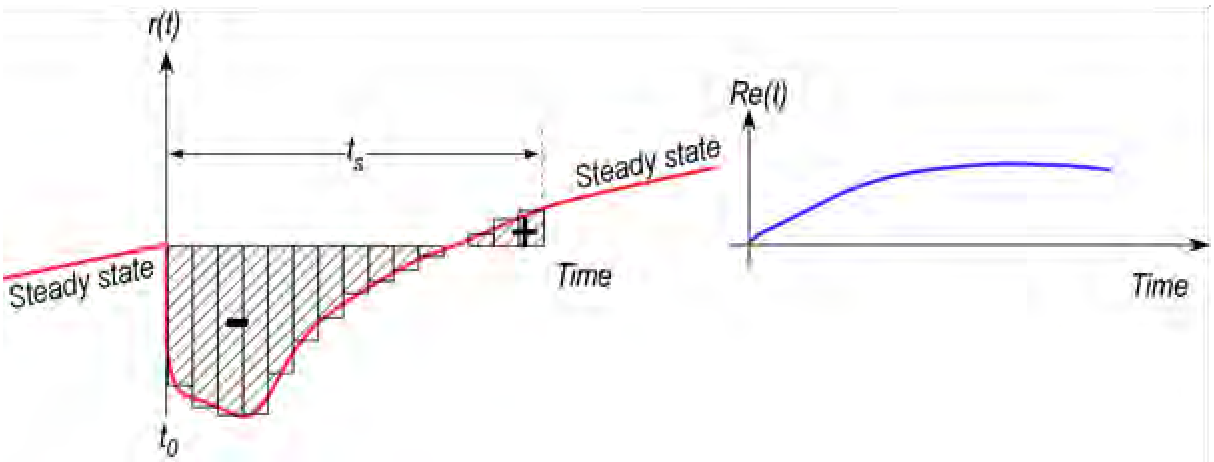


Figure 35. One scenario of post catastrophe recovery (from Jaboyedoff , 2010).

Based on their R4 Framework (resourcefulness, robustness, redundancy and rapidity), Tierney and Bruneau (2007) have conceptualized resilience for critical infrastructure systems (e.g. transportation and utility systems). Figure 36 plots the functionality of infrastructure after 50% loss, represented as the resilience triangle. Increasing resilience implies improving functionality to decrease the time of recovery and the resilience triangle.

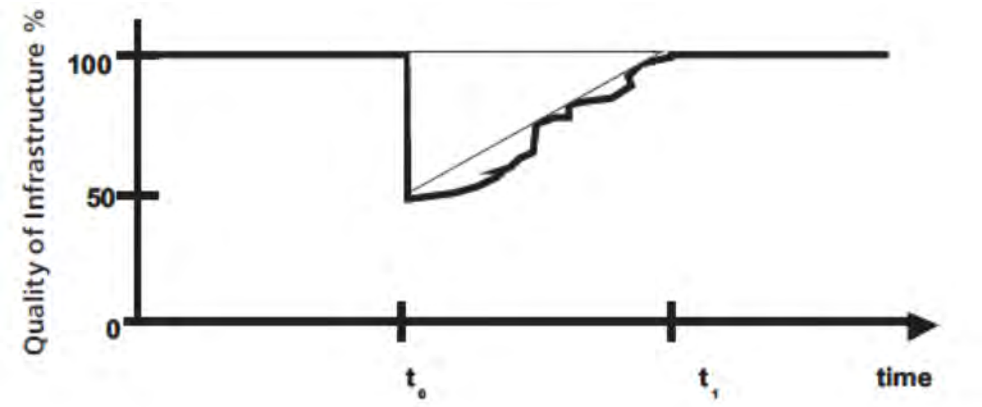


Figure 36. The Resilience triangle as a function of quality of infrastructure and time (from Tierney and Bruneau, 2007)

Mayunga (2007) has adapted the Sustainable Livelihoods Approach (section 3.6.9) to define resilience and proposes a number of indicators and methods for developing a community resilience index. As this framework offers the most holistic approach to describing resilience, we situate our work conceptually on the SLA and Mayunga's approach (Figure 37).

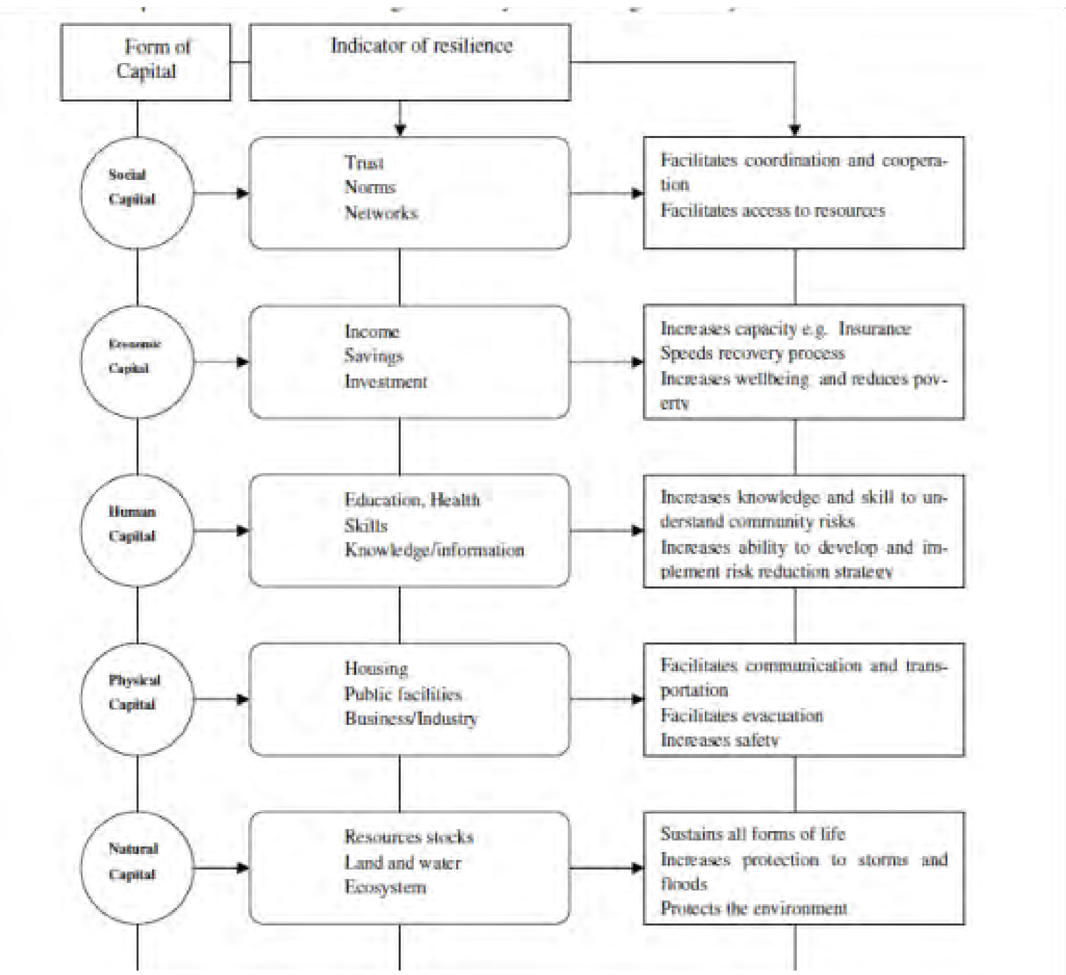


Figure 37. Sustainable livelihoods for resilience model Mayunga (2007)

Another interesting conceptualization of resilience is proposed by Zhou (2010), where resilience consists of three dimensions: time, geographic space and attributes (Figure 38). Attributes correspond roughly to the Sustainable Livelihoods Approach's 'five capitals' (Section 3.5.9). The criticism that can be made of this model is that we are not sure which part in time corresponds to resilience, or is it the entire disaster management process?

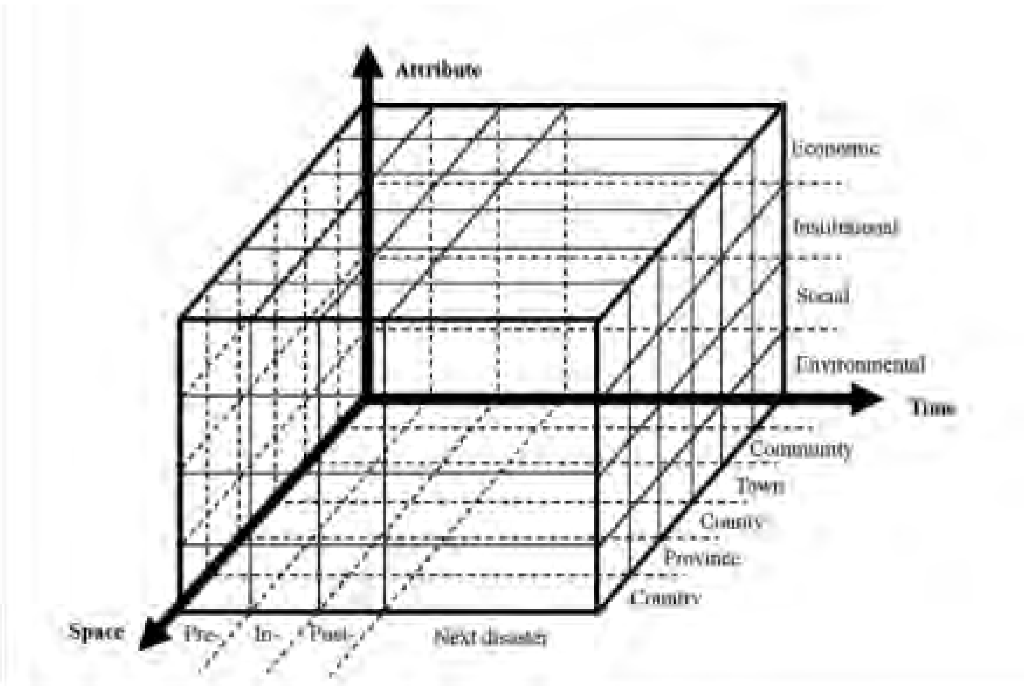


Figure 38. Resilience represented on three axes over time, space and attributes, (from Zhou, 2010)

3.5.4. Thresholds and resilience

An area of resilience that is not very well explored is the notion of critical thresholds that define the transition from one state to another (Renaud, 2010; Robert et al. 2010;). For organizational resilience, this concept has been developed to describe three different states: the reference (or normal) state, the disturbed state and non-functioning state of a system or organization (Figure 20). The so-called "performance threshold" marks the transition between the reference and disturbed state, or from normal organizational management to targeted management. Targeted management seeks to bring the organization back to its normal functioning. Between the disturbed and dysfunctional states, is the "failure threshold", which defines the transition to emergency management. Once the system is in a disturbed state and corrective actions are not effective, the system ends up in a dysfunctional state, requiring "emergency management" to bring the system at minimum to the disturbed state (Robert et al., 2010). Resilience is thus the amount of time and resources required to return an organization or system from a disturbed state back to a normal state.

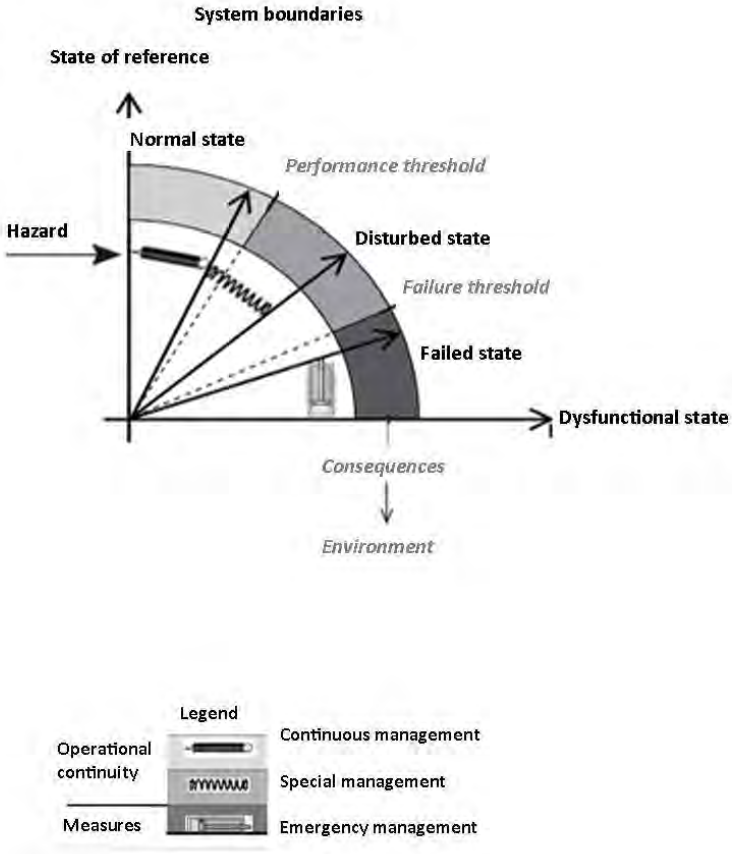


Figure 39. Diagram of organizational resiliency and system boundaries, thresholds and type of management. (Roberts et al. 2010. translated from French by Sudmeier-Rieux).

An example of a threshold in ecological system is the loss of filtering and productive functions of soils due to pollution and the degradation of their physical, chemical and biological properties. Degradation of these functions can take place over a short time frame, whereas the rehabilitation of these resources may require considerable investment over a longer time period (Renaud et al. 2010). Resilience is thus the time and investment required to return to the initial state, or an improved state.

How are these notions of thresholds from organizational and ecological resilience useful if applied to a mountain community in Nepal? Examples of a threshold to the non-functioning state for communities facing “everyday risk” such as food security- as well as shocks - such as landslides, would be an inability to function without external assistance. An example of a threshold from the “normal” to a “disrupted” state could be the need for outmigration for seasonal work, leaving women and children to deal with consequences of landsliding. However, the bottom-line issue is that communities at subsistence level have very low marginal capacities to deal with shocks and their thresholds leading to a non-functioning state may be easily transgressed. Again, the “normal state” is thus not necessary the desired state and cannot be addressed through emergency measures but rather long-term development interventions.

3.5.5. Concepts of resilience

In order to better situate the above definitions and models of resilience, the following table is intended to clarify the many approaches and authors who have written about resilience. Table 15 represents the most influential approaches to resilience grouped by discipline, not necessarily by importance.

Discipline	Approach	Author	Brief description
Socio-Ecological Science/ Sustainability science	Persistence of Systems	Holling 1973; Pimm, 1984	A measure of the ability of ecological systems to persist in the face of disturbance and maintain relationships between different elements of the system.
	Disturbance as Opportunity	Folke 2006	Equates resilience with the ability to use disturbances as occasions for doing 'new things, for innovation and for development.
	Stability, Self-organisation and Learning	Ostrom 1990; Carpenter et al. 2001 ; Klein, 2003	The amount of change a system can bear and '... still retain the same controls on structure and function', the capacity of a system to self-organise and the ability of a system to learn and adapt
	Ecological-social thresholds	Renaud et al., 2010	Defining thresholds from one state to another; the time and investment required to return to the initial state, or an improved state
	Context specific	Walker et al. 2006; Berkes et al. 2003	Specific resilience: resilience of what, to what? General resilience: capacity of system to deal with multiple pressures
Hazards and vulnerability research	Characteristics of Resilience	Twigg 2010	The ability of a community to absorb stress, capacity to manage, or maintain certain basic functions and structures, during disastrous events and the ability of a community to bounce back after a disaster. The UNISDR Hyogo Framework for Action is used to define areas for action: governance, risk assessment, knowledge and education, risk management and vulnerability reduction, and disaster preparedness and response
	Social cognitive	Paton et al., 2008	Resilience is based on an individual's motivation to prepare for, and act during a hazard event. This motivation is based on trust in authorities, self-efficacy, risk perceptions, outcome expectances.
	Community resourcefulness	Miletti, 1999; Buckle et al., 2000	A community can withstand an extreme event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community.
	Quantifying Resilience and vulnerability	Moench et al. 2007; NSCVT, 2009	Identify indicators and characteristics of resilience, assign weights and measure the impact of different variables. Hard resilience is the direct strength of structures or institutions when placed under pressure; and soft resilience is the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in function or structure
	Resilience sceptics	Lewis and Kelman, 2010; Gaillard et al. 2010;	The focus on resilience removes attention and resources from the need for structural change (i.e. power relations, market inequalities) to address vulnerability and risk of marginalized populations.

		Cannon and Müller-Mahn, 2010; Tobin, 1999	
	Resilience as Process	Manyena 2006	A focus on recovery as opposed to a singular concentration on resisting shocks, effective adaptation to disturbances.
	Five capitals Sustainable livelihoods approach and resilience	Mayunga, 2007	Characteristics of resilient systems spring from the sustainable livelihoods approach where social, economic, human, physical and natural capital are seen as the determinants.
Climate change adaptation research	Shock absorption	Timmerman, 1981	The measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event.
	Adaptation& Social Resilience	Adger et al. 2003; Adger, 2006	Social resilience, defined as the ability of communities to withstand shocks to their social infrastructure economic growth, stability and distribution of income, degree of dependency on natural resources, remittances and diversity in the kind of activities/ functions being performed within systems.
	Convergence between adaptation and resilience	Nelson, 2010	Explores convergences and tensions between resilience and climate adaptation. Adaptation, which effects change at local scale can undermine resilience, which encompasses the broader scale system.
Systems thinking and organizational change	Resilience Spectrum	Dovers and Handmer, 1992	Resilience is thought of as a continuum or spectrum broadly made up of three levels and applied to systems and organisations. Type 1 resilience is characterised by resistance to change; type 2 resilience is when marginal changes are made in order to make a system more resilient; and type 3 is when there is a high degree of openness, adaptability and flexibility.
	System resilience	Haimes, 2009b	That resilience of a system can only be measured in terms of a specific threat (input), the system's recovery time and the associated costs and risks.
	Organizational thresholds	Robert et al. 2010	Resilience is defined as the amount of time and resources required to return from a disturbed state back to the state of reference of a system or organization
	The R4 Framework	Tierney and Bruneau, 2007	Resilience is a dynamic process consisting of four components: Resourcefulness, Robustness, Redundancy, Rapidity.
Child psychology	Adaptation to threats in childhood	Masten, 1994	"Good outcomes in spite of serious threats to [child] development" require cumulative protection measures but cautions against the magic bullet myth of resilience
	Disturbance as a springboard	Cyrulnik, 1999	Disturbance provides an opportunity to bounce back beyond the initial state; resilience obtained only after having experienced a traumatic event but with higher than average rates of depression.

Table 15. Conceptualisations of resilience. Modified from Bahadur et al. (2010) and Zhou et al. (2010)

Among the above approaches, those that have provided the best insights for our work are Haimes (2009b) and the system's approach to resilience for its more rigorous way of defining resilience as compared to vulnerability; Mayunga (2007) for having linked the SLA with resilience; Moench et al. 2007 for distinguishing between hard and soft resilience and for elaborating on a method for quantifying vulnerability indicators; Twigg (2010) for the 170 indicators describing a disaster resilient community; and the "Resilience sceptics" for articulating inconsistencies with the way resilience is being projected by international development and disaster policies.

3.5.6. Characteristics and limitations of resilience

Based on this review of the literature and resilience models, the following section lists a number of positive as well as negative characteristics, or pitfalls of resilience. First, a summary of Twigg's characteristics, which recently underwent a review by leading U.K. NGOs. After field testing the full set of characteristics, Tearfund proposed its "top 20" list of characteristics (Twigg, 2010) (Figure 40). They have been divided into five thematic areas, which correspond to the UNISDR HFA.

Tearfund's Abbreviated Characteristics of a Disaster-Resilient Community ('top 20')

Thematic Area 1: Governance	Reference (full list of Characteristics)
• Committed, effective and accountable community leadership of DRR planning and implementation.	• 1.5
• Capacity to challenge and lobby external agencies on DRR plans, priorities and actions that may have an impact upon local risks.	• 7.4
• Evidence that disaster risk is being taken into account in planning developmental activities.	• 3.1 & 4.1
Thematic Area 2: Risk Assessment	
• Participatory hazard/risk, vulnerability and capacity assessments carried out and updated, which provide a comprehensive picture of all major hazards/risks, vulnerabilities and capacities in the community.	• 1.1 & 2.1
• Community uses indigenous knowledge and local perceptions of risk, as well as other scientific, data-based assessment methods.	• 3.2
Thematic Area 3: Knowledge and Education	
• Possession of appropriate technical and organizational knowledge and skills for risk reduction and disaster response at local level (e.g. indigenous technical knowledge, coping mechanisms and livelihood strategies).	• 1.4
• All sections of community know about contingency plans, facilities, services and skills available pre-, during and post- emergency, and how to access them.	• 2.3
• DRR knowledge is being passed on formally through local schools and informally via oral tradition from one generation to the next.	• 3.1
Thematic Area 4: Risk Management and Vulnerability Reduction	
• Food and water supply secure in times of crisis (e.g. through community managed stocks of grain and other staple foods; protected or stored water supplies).	• 2.3 & 2.4
• Livelihood diversification at household and community level, including on-farm and off-farm in rural areas, with few people engaged in unsafe livelihood practices or hazard-vulnerable activities.	• 3.3 & 3.4
• Adoption of hazard-resistant agricultural practices and sustainable environmental management (e.g. soil and water conservation, flexible cropping patterns, hazard-tolerant crops, forest management).	• 1.2 & 3.5
• Existence of and access to community savings and credit schemes, and/or a community disaster fund to implement preparatory, responsive or recovery activity.	• 5.3 & 5.5
• Structural mitigation measures in place (e.g. water-harvesting tanks, embankments, flood diversion channels).	• 6.4
• Houses, workplaces and public facilities located in safe areas or hazard-resistant construction methods in use.	• 6.3, 6.5 & 6.6
• Measures in place to protect key assets (e.g. livestock) and items of domestic property (e.g. use of raised internal platforms or plastic containers).	• 6.8
Thematic Area 5: Disaster Preparedness and Response	
• Accessible emergency facilities and equipment available (for shelter, communications, rescue, etc.), owned and managed by the community.	• 1.6
• Community-based and people-centred early warning system in place at local level, producing messages which are trusted and understood by whole community.	• 2.1 & 2.3
• Community and family level contingency plans exist, developed and owned by the community, linked to higher-level plans and practised regularly.	• 3.2, 3.3 & 3.7
• Community has the capacity to provide effective and timely emergency response services, including training and deployment of volunteers with appropriate skills (e.g. search and rescue, first aid, managing emergency shelters, fire-fighting).	• 5.1 & 6.4
• Community has appropriate plans and mutual support systems in place to take care of the most vulnerable – usually the elderly, disabled, AIDS-sufferers, mothers and young children.	• 6.7

Figure 40. Tearfund's top 20 list among Twigg's disaster resilient characteristics (from Twigg, 2010)

Based on this literature review, here is a list of the ten most common characteristics of resilience:

- Diversification (e.g. multiple sources of income, back-up power systems, or **redundancy**)
- Time and cost effectiveness (e.g. short recovery period after a crisis, or **rapidity**)
- Access to resources (e.g. savings, family ties, power, natural resources, education, information, or **resourcefulness**)
- Buffering capacity of a social or natural system to absorb shock (e.g. due to natural, physical or economic protection measures, or **robustness**)
- Self-organization, preparedness, planning and readiness (e.g. early warning, protection measures and first aid)
- Ability to learn and improve after an event (e.g. preparedness increases after every crisis)
- Effective governance/institutions/control mechanisms (e.g. civil protection, zoning enforcement to reduce exposure)
- Community involvement and inclusion of local knowledge in planning (e.g. local risk maps and evacuation plans)
- Critical thresholds are identified and monitored to improve recovery (e.g. e-coli bacteria amounts in drinking water are monitored and addressed before critical level is reached)
- Flexibility (e.g. within organizations, livelihood systems, economic systems, water management systems)

Source: Baladur et al. (2010); Moench et al. (2007); Tierney & Bruneau (2007); Twigg (2010);

We note that of the above 10 characteristics, most can be considered related to capacities and knowledge, referred to by Moench et al. (2007) as" soft resilience", or, "the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in function or structure" versus "hard resilience, which is "the direct strength of structures or institutions when placed under pressure" (Moench et al. 2007).

3.5.7. Summary of limitations and caveats of resilience

The following summary of the limitations and caveats of resilience is also based on the above literature review:

- Multiple and conflicting definitions, a "catch-all phrase";
- "Magic bullet" status with few operational frameworks to guide policies and practices;
- Resilience may be a false objective as it does not necessarily reduce vulnerability, nor risk, which require structural measures aimed at governance, market inequalities;
- Obtaining resilience has a cost and requires investments: how to ensure that these are well-placed?
- A return to the normal state is not always possible, nor desirable as this state may be part of the problem.

A measure of resilience can be useful to NGOs and policy makers if it responds to a number of defined criteria:

- Establish clear boundaries for what resilience means and if possible, defined by the target population;
- Context specific to ensure that any measures are relevant to the target audience;
- Threat specific as a population might be resilient to one threat but not another.

3.5.8. Convergence between risk, vulnerability, resilience, adaptation and coping capacities?

Some questions raised by this review of vulnerability and resilience are: what is the relation between risk, vulnerability and resilience? Do we need resilience in order to define risk? If resilience of a population increases, would this necessarily reduce vulnerability and risk? What is the difference between resilience, adaptation and coping capacities?

From a system's perspective, Haimes (2009b) states that vulnerability and resilience are both manifestations of a system; vulnerability only addresses a system's protection, whereas resilience also focuses on its recovery following a shock. Vulnerability represents those subsets of a system that can be adversely affected by a certain magnitude and types of threats, whereas resilience – in addition – represents the ability of the system to recover within an acceptable time and composite costs and risks (Haimes, 2009b). Haimes (2009b) concludes: "*the vulnerability of a system does not provide information about the ability of a system to recover from a particular threat*." Likewise, the opposite is also true: recovering from a particular threat may not reduce a system's vulnerability or risk, as resilience implies a return to the pre-disaster state. In other words, a population can be vulnerable and at risk, while simultaneously resilient. Nelson (2010) gives the example of rural populations in north-east Brazil living in persistent vulnerability, yet nested within a social-ecological system that is actually quite resilient. Social factors, (e.g. economics, governance) have degraded environmental conditions and reflect ultimate causes of vulnerability. He concludes that neither resilience, nor adaptation efforts may be sufficient to address the ultimate causes of vulnerability (Nelson, 2010).

Thus resilience may be a useful concept to describe a more efficient recovery process after a crisis as one step in the disaster management cycle, but will not necessarily change a population's everyday risks, well-being or reduce vulnerability. The concept therefore parallels coping capacities, or recovery strategies for dealing with shock and adversity, rather than favoring long term capacity building to reduce underlying vulnerabilities. As mentioned in section 3.3.2, Burton et al. (1993) distinguish between adaptation- and coping strategies as a function of the type of threat, and length of time required for a population to reduce risk. Adaptation is a longer term process, while coping is short-term. Both require making adjustments to livelihoods based on decisions and choices following an appraisal of events and possible outcomes or consequences (Burton et al., 1993; Lazarus, 2010).

3.5.9. The sustainable livelihoods approach

The Sustainable Livelihoods Approach (SLA) is presented here as one model that combines vulnerability and resilience, without explicitly doing so. It was developed in the 1990s by academics and the U.K. International Development Agency (DFID, 1997; Scoones, 1999). It has already been operationalized by many development-oriented NGOs and is considered the standard approach to understanding livelihoods and vulnerability (Turrall, 2011). It has however not been employed to a great extent by DRR practitioners as development and DRR are only beginning to converge (Warburton & Pasteur, 2011).

Sustainable livelihoods are the basis for life and human security, and are therefore the basis for effective risk management. Conway and Chambers (1992) define sustainable livelihoods as follows: 'A livelihood comprises people, their capabilities and their means of living, including food, income and assets. Tangible assets are resources and stores, and intangible assets are claims and access. A livelihood is environmentally sustainable when it maintains and enhances the local and global assets on which livelihoods depend, and has net beneficial effects on other livelihoods. A livelihood is socially sustainable which can cope with and recover from stress and shocks, and provide for future generations. Livelihoods thus refer to the means and capacities required to sustain durably people's basic needs: food, shelter, clothing, cultural values and social relationships (Gaillard and Cadag, 2009). Communities that have weak livelihoods are likely to be more vulnerable to a hazard as they often lack the resources to draw upon during a disaster, they may be inadequately protected or have little influence with local authorities for receiving compensation.

We therefore base our work conceptually on the SLA, which defines livelihoods as access to five basic capitals or resources: social, human, economic, natural and physical (Figure 41). It also suggests a framework for assessing the vulnerability context, the five livelihood assets (or resources), transforming structures and processes (i.e., institutions, legal frameworks, land tenure regimes) to which access depends on levels of influence and access. These factors define the options available for livelihood strategies (or coping strategies), in order to achieve a variety of livelihood outcomes. Livelihood outcomes can be defined by a number of indicators that ought to be locally specific but could generally defined as well-being (i.e., economic, health, psychological).

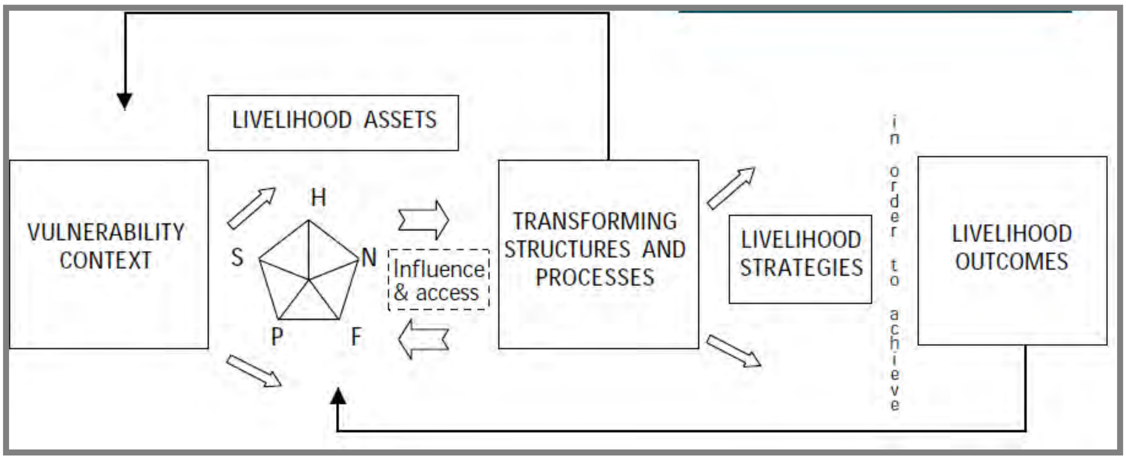


Figure 41. The Sustainable Livelihoods Framework (modified from DFID, 1997)

In addition to understanding the vulnerability context, transforming structures and processes and livelihoods strategies, the SLA refers to five capitals:

i. Human capital - health, skills, formal and informal knowledge;
ii. Social capital - networks, informal institutions, relationships of trust and exchanges;
iii. Natural capital - most services offered by ecosystems such as food, fiber, drinking water, clean air and protection from hazards (i.e. wetlands for flood abatement);
iv. Physical capital - infrastructure such as roads, secure shelter, water supply and sanitation, schools, access to information – communications and tools such as sewing machines and kilns;
v. Financial capital - savings in the form of liquidities, or available credits, or reliable pensions and remittances.

vi. A sixth category has been suggested in addition: Institutional or political capital - formal arrangements, legal structures and access to power and influence (modified from Gaillard and Cadag, 2009). The five (or six) capitals are clearly interrelated, overlapping, including both tangible and intangible assets.

This approach has been criticized for being overly economic and overlooking different types of resources, gender issues and being too small-scale (Turall, 2011). Yet, SLA is still considered a useful framework for highlighting interlinkages between various types of resources as well as root causes and the 'enabling environment'. The aim of basing risk management on the SLA is to be able to target investments for strengthening and diversifying assets so they remain a reliable resource and coping strategy in the event of a disaster. Livelihoods can be strengthened by physical measures, such as building irrigation schemes and defensive walls along a river embankment, or by capacity building, such as agriculture service centres that supply seeds, information and provide training and skills for agriculture and fisheries, or emergency rescue skills (Practical Action, 2010). The SLA is the basis for this study's conceptual framework as it offers a relatively simple, straightforward method with some proposed modifications, as discussed in the methodology chapter (Chapter 4) and discussion chapter (Chapter 7).

3.7. Conclusions – vulnerability and resilience

This literature review of main concepts, models and definitions of vulnerability and resilience has provided us with a theoretical background for framing our research. Contrary to some of the recent literature (Adger et al. 2005; Cannon, 2007), this study maintains that vulnerability (a degree of weakness) is not the direct opposite of resilience (capacity to assimilate a negative impact and recover). ***Rather, it is the ability of a system, community or household to change in a positive manner, faced with adversity*** . In the aftermath of adversity, such as a disaster, a resilient system is one that leads to positive outcomes, whereas a negative outcome leads to dysfunction and vulnerability (Masten, 2001). Furthermore, resilience and vulnerability only exist if there is a threat, a hazard, thus risk. Where the literature is still lacking is providing credible models linking resilience, vulnerability and risk. The relation between these concepts is not linear and has yet to be thoroughly addressed.

We also note the large number of definitions of vulnerability and resilience, especially between the DRR and CCA communities. This is creating confusion and tension between the two, in spite of attempts to merge and conciliate at the policy level. Füssel's (2007) model of internal and external domains of vulnerability factors helps us identify the resilience versus vulnerability spheres of action. This researcher considers resilience to describe the 'internal sphere' and interactions within and between the internal and external spheres.

In its strictest definition, especially that of IPCC, one of the strongest criticisms of resilience is the return to conditions that prevailed before a hazard event, or the vulnerable conditions that contributed to the disaster happening in the first place (Lewis and Kelman, 2010). "[The] *concern of resilience is often with exposure or propinquity to sources of hazard and to an evident status quo of conditions and their consequences, not with the causes of that exposure, decrepitude or disadvantage nor, therefore, with the vulnerability process*."

In most cases, a return to normal conditions may not be feasible, or desirable. Rather, resilience can be useful if seen as a process during the recovery period after a disaster in contrast to vulnerability, which is often caused by structural inequalities and limited access and rights to resources. As Lewis and Kelman (2010) state: "*resilience, moreover and in all its contexts, may give up, fail, or be overwhelmed. It is less community capacity that is in question than the capacity of resilience itself*." In this context, resilience implies putting into place recovery strategies and emergency preparedness rather than addressing deep-seated conditions that led to vulnerability in the first place. In this light, more authors are questioning whether resilience is such a desirable goal of international development policies and programs (Tobin, 1999; Lewis and Kelman, 2010; Gaillard et al. 2010; Cannon and Müller-Mahn, 2010). Critics of resilience compare resilience to a "bandaid", or preparedness measures to render recovery more effective, rather than addressing long-term underlying vulnerabilities. In the field, NGOs are using the resilience "golden egg" or "bandwagon" to tap into new funding sources while continuing to address population vulnerability, by adding a dash of DRR and a dash of CCA (Ayers et al., 2011). And it's working. The problem now is to develop a means for evaluating whether resilience goals are being met without neglecting risk or vulnerability.

Among all approaches described above, those most appropriate for this study's goals and conceptual framework are "Five capitals and sustainable livelihoods for resilience" (Mayunga, 2007) as well as Moench and Dixit's (The Risk to Resilience Team, 2009) "Quantifying Resilience and Vulnerability". These two approaches constitute this study's conceptual framework, the SLA for the simple yet holistic approach to analyzing both vulnerability and resilience, and Moench and Dixit's approach for having developed a first framework for developing indicators of resilience. From a methodological viewpoint, Bollin and Hidajat's (2006) "Community based disaster risk index" provides a model for the risk-resilience index developed by this study. The following chapter describes the methodological underpinnings methods of this study and our attempt to address the literature gap linking risk, vulnerability and resilience.

Methodology

4.1. Introduction

The methodology of this thesis combines “bottom-up” qualitative and quantitative participatory approaches with “top-down” quantitative geological assessments, remote sensing and a geographic information system (GIS) database. The study used a case study approach, combining well-tested participatory qualitative methodologies, typically used in Vulnerability and Capacity Analyses, such as semi-structured interviews with so-called ‘key informants’, transect walks, participatory risk and resource mapping to understand how the community functions, relations between groups, coping strategies, identify stakeholders, vulnerable households and dangerous areas (Anderson and Woodrow, 1998; Chambers, 1994; Cornwall and Jewkes, 1995; Kafle and Murshed, 2006). The participatory risk mapping exercises especially provided a means for improved communications about risk between community members and scientists (Bryan, 2011; Maceda et al. 2009; Vajjhala, 2005).

The scale of the study is at the community and household level. The field sites were selected to represent high landslide risk situations, yet different land use histories and ethnic compositions. Several scoping studies were conducted in October 2008 and April 2010, before and toward the end of the rainy season, mainly focusing on the geological situation of each village, followed by an in-depth socio-economic survey in October 2009 and October 2010 with several teams of researchers, at minimum, two geologists and two social scientists of which two were native Nepali speakers. Approximately one week was spent in each village.

The study is based on 168 semi-structured household surveys, circa 50% of each village, using purposeful sampling and every fifth house in the urban areas, combining purposeful and random sampling. Results were tabulated in excel tables and open ended questions were analyzed manually. In addition to being subject to higher risk, women are known to have different perceptions and responses to risk than men (Enarson, 1998; Fordham, 2003). Therefore, separate focus groups were held for women and men with a total of ca. 60 persons participating in focus group discussions. Sessions were recorded, translated and a manual content analysis was conducted to detect main trends. Participatory mapping sessions initiated each village study, led by 5-8 self-selected persons from each community, using only a poster size blank sheet of paper and colored pencils. The only indication given to participants was to map the most important features of their community and for the Dolakha communities, to color code houses according to how participants interpret high risk (red), medium risk (orange) and low risk (green). In general, men drew the maps, with women adding or removing features afterwards. Secondly, men and women were separated into groups of 8-10 persons to conduct a modified SWOT analysis or "social mapping" of their resources and main threats and priorities, as a self-assessment of risks, resources and threats (Wisner, 2006). Finally, a household survey was conducted, with a purposeful sampling of households to ensure than households within a high risk (< 100 meters) and low risk (>100 meters) perimeter from the landslides were questioned. Each household surveyed was geo-referenced using a Geographic Positioning System and located on a high-resolution satellite image. Results from the household survey were then transferred into a GIS and compared with a "geologist's" risk map using a definition of risk commonly used by geologists:

Landslide risk = hazard (expected return time of event) * vulnerability (% of total potential loss) * exposure (est. time spent in landslide zone) Modified from Einstein (1988)

This chapter sets out to justify and describe the epistemological and methodological foundations of this study. It is organized according to the following five principles that have guided this research:

- Iterative: based on grounded theory, permitting both inductive and deductive approaches;
- Interdisciplinarity: bridging social science and natural science approaches to landslide risk;
- Participatory: based on community-based disaster risk reduction;
- Pragmatic: problem-based, operational, indicator development;
- Credible: based on a triangulation of research methods commonly used in social sciences.

The choice of these above principles are based on a combination of conviction, educational background, work experience and personal constraints of time that shaped research possibilities.

4.2. Iterative: based on grounded theory

This iterative approach is the basis for grounded theory, a well-established qualitative method for developing theories and conceptual frameworks in a way that is both inductive and deductive (Strauss and Corbin, 1998).

"*Grounded theory research begins with an explorative and iterative approach to data collection and analysis aimed at producing theory, particularly in realms where no clear theoretical framework exists, or where there are multiple competing theoretical frameworks in the literature. If gaps appear in the theoretical models developed from initial interviews, documents, and observations, then the investigators continue ''sampling'' to fill the gaps and explore inconsistencies in those models*" (Polsky et. al., 2007: 481).

Grounded theory was proposed by Glaser and Strauss in 1967 to counter criticisms of social science methods as lacking credibility compared to natural science methods. The theory has evolved from its positivist roots (e.g., Glaser, 1992; Guba and Lincoln, 1994), to post-positivist methodologies (Strauss and Corbin, 1998), to constructivist approaches (e.g., Charmaz, 2000) (quoted by Polsky et. al., 2007). It has been used in several types of social science research, including health sciences. The concept of "grounded assessment" has evolved from the a purely qualitative grounded theory by "*incorporating a mixed-methods approach, grounding itself both in empirical qualitative data and quantitative data*"

(Polsky et. al., 2007). Thus, grounded theory and assessments provide an appropriate epistemological foundation for the study, especially relevant for problem-based and interdisciplinary research, requiring new approaches based on local context and the local needs.

4.2.2. Case study research

The case study approach lies in the heart of grounded theory and is typically based on two or more methods of data collection. Hakim (1987) describes case studies as the social research equivalent of the spotlight or microscope. Case studies normally focus on one or more selected examples of a social entity such as communities, organizations and families. Selection of cases for study lead to a descriptive report of the samples to provide a rigorous test of a well-defined thesis (Hakim, 1987; Yin, 1984).

"Whether the case study is descriptive, exploratory, or concerned with rigorous tests of received ideas, the use of multiple sources of evidence and, very often, multiple investigators makes the case study one of the most powerful research designs" (Hakim, 1987:65).

Even if the number of cases remain small, the importance of case studies increases with the number of cases that cover different types of communities, or the issue to be studied. A good case study has a high degree of fit between the question to be addressed and the particular cases selected for the study. The case study approach is especially appropriate for this study as multiple methods were used to understand several communities and the issues they face. Two main challenges face case study research: the analysis and presentation of case study data in a robust and selected manner in order to respond to research questions without presenting research bias; secondly related is the ability of the researcher to distill main lessons from research findings in order to come to generalizable conclusions about the research (Yin, 1984).

4.3. Interdisciplinary approach

As a social scientist with a background in international development (MA) and forestry resources (MSc), working with geologists to understand landslide risk, this research was from the outset interdisciplinary, if not transdisciplinary[3]. The value of such an approach was also recognized by SNSF, which provided funding for this research from their interdisciplinary division. However in spite of the much lauded need for more interdisciplinary research, in reality there continues to be a little of it, perhaps due to the extra complexity, headaches over definitions, trade-offs and compromises required, not to mention the relatively few journals that publish interdisciplinary research. According to Lélé and Norgaard, 2005, interdisciplinarity is about working across - and crossing boundaries - not always an easy task in academically defined disciplines, divided into departments, which do not always work together, nor are especially rewarded for making this extra effort. Lélé and Norgaard (2005) articulate this tension inherent between social and natural sciences by identifying four major types of barrier to interdisciplinarity:

- *"First, there is the problem of values being embedded in all types of inquiry and at all stages: in the choice of questions, theoretical positions, variables, and style of research. But certainly natural*

[3] Jean Piaget introduced this term in 1972 and defined as: "a new space of knowledge "without stable boundaries between the disciplines", with the goal of leading to new more holistic solutions to real-world problems.

scientists, and even social ones, are loath to acknowledge the presence of value judgments in their work.

- *Second, researchers in different disciplines may study the same phenomenon but differ in their theories or explanatory models (and underlying assumptions). In the case of complex phenomena, it is not easy to prove the superiority of one theory over another in a particular case. Maintaining allegiance to one's school of thought may come to seem more important than openly exploring which explanation seems to work better in a particular context.*
- *The third type of barrier is the one that has been most emphasized in the literature on interdisciplinarity: the differences in epistemology and hence in specific methods, notions of adequate proof, and other fundamental assumptions of different fields.*
- *Finally, the way in which society interacts with and organizes academia influences the production of interdisciplinary research. " (Lélé and Norgaard, 2005:968).*

This latter point refers mainly to the often higher value placed by society and academia on the natural and engineering sciences with more quantitative approaches versus social sciences or "the arts", due to the high role placed on technological solutions in modern society. This bias toward natural and engineering sciences is also cultural. However, in defense of social sciences, DeCanio 2003 (as quoted by Lélé and Norgaard, 2005) contends that:

"*Not only has quantitative thinking been extensively adopted in the social sciences, but, more important, qualitative thinking can be as rigorous as quantitative thinking, and quantitative thinking does not prevent bogus rigor arising out of patently wrong assumptions" p.970).*

In spite of the drawbacks, interdisciplinarity remains a defendable concept, as in the long run research results are often more applicable to real-world problems, rather than serving disciplinary and theoretical purposes. Even as social science qualitative methods may at times have been considered less credible and rigorous than the quantitative methods used in natural sciences, this experience with interdisciplinarity has overall been positive and resulted in more rigorously defined concepts and methods. One example of interdisciplinary and problem-based approaches are integrated risk assessments as promoted by Swiss Development Cooperation (SDC) (Stössel, 2004) and other academics and practitioners (Weichelgartner and Sendzimir, 2005; Alcantara-Alaya, 2005; Zimmermann, 2004). Integrated landslide assessment methods, as developed by (Fell et al., 1997; Leroi et al., 2005; Alcantara-Alaya & Goudie, 2010) are especially relevant to studying landslides in a developing country context.

"One method of preventing, predicting, and managing landslides is through integrated risk assessments for understanding the geological, environmental, and social contexts in which landslides occur (Crozier and Glade 2004; Leroi et al., 2005) (Figure 2). Integrated risk assessments require bringing together data across disciplines. Methods for each context are not new, but the novelty lies in the interdisciplinary coordination. Proponents argue that even if upfront costs for integrated risk assessments may be time consuming and costly, this investment is necessary for prevention measures and reconstruction efforts to be effective and sustainable (Zimmermann and Issa 2009)" (Sudmeier-Rieux et al., 2011a: 113).

The next section will explore another interdisciplinary and participatory approach to risk assessments and disaster risk reduction: Community-Based Disaster Risk Reduction.

4.4. Participatory approach

4.4.1. Community-Based Disaster Risk Reduction

Another example of an interdisciplinary approach to reducing risk is through community-based disaster risk reduction (CBDRR). This approach has been strongly promoted in the past decade by regional organizations such as the Asian Disaster Preparedness Center in Bangkok, NGOs and governments (Abarquez & Murshed, 2006; Kafle & Murshed, 2004). CBDRR combines a number of well-established social science research methods mainly emanating from the Rural Rapid Appraisal participatory research methods developed by Robert Chambers in the 1980s and 1990s (Chambers, 1983; 1994; 1995; 1997) with various risk assessments. Other terms used are Participatory Research Approach (PRA) or Participatory Action Research (PAR). Besides being interdisciplinary, CBDRR is increasingly promoted by NGOs and governments for its emphasis on enhancing community capacities to address disaster risks. The basic idea of CBDRR is community capacity building and community organization for disaster risk reduction and to improve communications with disaster management authorities. To this end, it emphasizes participatory approaches and community involvement throughout the process.

Thus, one of the key characteristics of CBDRR is participation, or transferring ownership of disaster risk reduction to the people who are affected by disasters. Many of the CBDRR tools are the same as those used for Vulnerability and Capacity Analysis (Anderson & Woodrow, 1998) and widely adopted by humanitarian agencies such as the International Federation of Red Cross and Red Crescent societies prioritizing communities in a crisis or post crisis situation. The ideal premise of participation is empowerment: to improve participants' understanding of their situation, equitable participation in the inquiry and analysis, and create strong networks. In other words, researchers and NGOs conducting participatory research need to be very cognizant of different power relations between themselves and the community being researched. Ideally in participatory research, both researchers and communities learn from each other in a win-win situation. Thus, communities are not just supposed to be research objects, as may be the case in ethnographic or anthropological research.

Participatory research has greatly influenced applied social science research, however when a team of foreign researchers come to a small village, expectations are often raised about what the foreigners will bring or do for the community. i.e. find a solution to reduce landslide risk. The situation may be somewhat different for researchers arriving with only research budgets, as compared to NGOs conducting participatory research as a baseline before establishing project activities. Therefore there is a fine line as a researcher between all the information obtained from the community for research and what the community received in return in order to keep the balance win-win.
Other attributes of participatory methods for integrated risk research are its cost effectiveness, and offering ways of investigating and identifying causality of risk (Dekens, 2007). In other words, participatory research is an effective way of not only describing the landslide phenomena, but also for understanding the reasons why they occur in this location and why they are creating risk for population. The causal link between landslides and land use may be impossible to understand with pure geological methods, without consulting the population to understand land use history, recurrence intervals and how the population has reacted (or not reacted) to landslide risk.

4.4.2. Participatory research tools:

- **Community drama** - enables people to express what happens during disasters and why
- **Focus groups discussions** - can be a powerful way of understanding group dynamics, can enable people to better remember events in a group situation but needs to be properly managed so as to allow less vocal community members to express themselves, such as women and youths
- **Gendered resource mapping and gendered benefit analysis** – shows differences in access to and control over resources between men and women in households and in the community
- **Historical profiles and time lines** - reveals how people cope with adverse events in the past
- **Institutional and social network analysis** - formal and informal service structures for delivery of community services
- **Livelihood analysis** - gives a picture of the varying effects of hazards on different households and groups
- **Problem tree and Ranking** - shows linkage of vulnerabilities and enables the community to express the priority vulnerabilities to address
- **Participatory risk or hazard mapping** - shows people's own representation of their land use important elements of their village and how the perceive hazards and risk
- **Seasonal calendar** - visual presentation of economic activities, coping strategies, availability of money and time; gives insight on periods of stress, diseases, hunger, debt, etc
- **Transect walk** - helps to get a better understanding of the community map and affords opportunity to ask more questions on physical/material vulnerability
- **Venn diagram** - shows the state of coordination among organizations and Government agencies or leadership patterns

Modified from (Abarquez & Murshed, 2006)

Each of the above participatory research tools has its pros and cons, either in terms of level of community participation, reporting, or analysis (Pretty et al., 1994). Most of the above tools are qualitative and can be used in conjunction with more quantitative research methods. Some issues and concerns with participatory research include:

- **Issues of standardisation**: "*The more standardised the process, the more extractive and less empowering and accommodating of local priorities and realities it is likely to be. The less standardised it is, the harder the outcomes are to analyse*" (Chambers, 2007:27)
- **Scale, quality, time, resources, and ethics**: the issues here are far from simple. Smaller scale, more time, and more resources can allow for higher quality and better ethics but loss of representativeness; and vice versa.
- **Quality of facilitation versus speed, scale and cost of implementation**. In these approaches, the quality of facilitation is critical. To achieve good facilitation requires time and resources devoted to careful selection of facilitators, their training and then their supervision in the field. This may add to costs and slow implementation and limit its scale, even if the outcomes are still highly cost-effective compared with alternatives.
- **Representation:** *"Where groups are involved, and as is well known with focus groups generally, those who are most easily convened may be unrepresentative or dominated by one or a few people, or by one sort of person (for example, men in a mixed group of men and women). Care in selection, in judging size of group, and observation and facilitation of process can offset these dangers but takes time and effort and can entail a loss of spontaneity"* (Chambers, 2007:28).

- **Cost-effectiveness**: participatory methods are often more cost-effective than standard questionnaires as it is possible to obtain more information from a group of people during one hour from one household interview; however it cannot be assumed that participants will necessarily benefit and care must be taken to ensure that participants also benefit from the exchange of information.

  "participatory methods may be more cost-effective for researchers, but more time-consuming for participants. Blocks of people's time are taken. These have opportunity costs. Some seasons(e.g. when weeding is needed) these may be very high indeed. Much PRA practice is extractive more than empowering and data is often removed for analysis outside with little left in the community itself. Expectations are liable to be raised. Participatory approaches are vulnerable because of the interest and enthusiasm often generated" (Mayoux and Chambers, 2005: 285).

4.4.3. Participatory numbers

Early criticism of participatory tools were that they are overly qualitative, subject to research bias in reporting and interpreting findings: "*such research may be dismissed on grounds of lacking conventional rigor*" (Mayoux and Chambers, 2005: 272). In recognizing the need for reporting participatory research findings in ways more acceptable by policy makers, Chambers (2007) suggested a combined qualitative and quantitative method, which he called "participatory numbers". By combining participatory methods with statistics, findings can be generated with a high degree of validity (Mayoux and Chambers, 2005). "Participatory numbers" uses many of the same participatory methods but in addition, researchers may ask participants to rank and prioritize by using locally appropriate methods of quantification, i.e., by giving participants pebbles or beans to place next to items to be ranked (Chambers, 2007). Participatory numbers is therefore also an appropriate method for developing indicators that are locally relevant.

"The issue is therefore not to measure 'complete objective truths', but to establish a systematic way the most relevant indicators for the question in hand – a process which is inherently subjective and partial" (Mayoux and Chambers, 2005:272)

While quantitative multiple choice household surveys may be criticized for being reductionist, a comparative advantage of participatory, qualitative research is "*the quality of authenticity in presenting realities and expressed priorities of marginalized populations*" (Mayoux and Chambers, 2005:273). Four additional benefits of participatory numbers are: validity and reliability; insights into sensitive subjects; unexpected findings with policy implications; and power and learning (Chambers, 2007). Considering our society's bias for quantifying, measuring and comparing in order to more effectively transmit research findings for policy recommendations, participatory numbers is a way of increasing credibility of participatory qualitative research.

The following section justifies why this research was designed to be problem-based and pragmatic, using a combination of participatory qualitative and quantitative methods together with more conventional quantitative and questionnaire surveys.

4.5. Pragmatic and problem-based

Interdisciplinarity is commonly used in applied research and often has roots in the so-called 'pragmatic theory' or epistemology (Pietarinen, 2006). Following 'pragmatic epistemology', knowledge consists of models that attempt to represent the environment in such a way as to maximally simplify problem-solving, which is chosen depending on the problems that are to be solved. "*The basic criterion is that models should produce predictions, which may be tested or problem-based solutions, and be as simple as possible. There is an implicit assumption that models are built from parts of other models and empirical data on the basis of trial-and-error complemented with some heuristics or intuition*" (Heylighen, 1993). 'By contrast, constructivism assumes that all knowledge is built up from scratch by the subject of knowledge. There are no 'givens', neither objective empirical data or facts, nor inborn categories or cognitive structures (Heylighen, 1993). Pragmatic models are thus entirely inductive.

The study's research objectives and questions are very much problem oriented and focus on answering pragmatic methodological questions following both inductive and deductive methods: how to operationalize resilience and its relation to risk and vulnerability; and secondly to answer real-world questions: to understand which populations are most affected by landslides, how are they coping with landslides and what can be done to reduced landslide risk. For the first part on resilience, a new methodology was designed, based on a review of the literature and field observations, to develop indicators for measuring resilience. For the second part of landslides, an existing methodology to assess risk, commonly used by geologists was modified to also take into account other characteristics of vulnerability, other than physical.

Considering the research questions, this study is inherently pragmatic or applied and problem-based. Since one of the research goals is to develop tools and guidance for measuring or operationalizing resilience, research outputs also need to be replicable and comparable between communities, if not between households. This is why the emphasis is placed on quantifying and measuring resilience, not because of any conviction that quantitative methods are superior to qualitative methods. The landslide risk assessment methodology has been modified in two ways: simplified to be replicable in a data poor environment while using indicators for measuring the multiple facets of vulnerability (natural, social, human, environmental, as well as physical).

The next section goes into more detail on methods used for developing vulnerability and resilience indicators.

4.5.1. Developing indicators

There are of course many different ways for developing indicators, and there are many different types of indicators. The main 'raison d'être' of an indicator is to simplify and communicate scientifically robust measures of the status or change in condition as well as providing a benchmark against which it is possible to monitor how the condition evolve. A good indicator is considered SMART (Specific, Measureable, Achievable, Relevant and Timely), in addition to being clearly understandable.

"An indicator is a pointer. It can be a measurement, a number, a fact, an opinion or a perception that points to a specific condition or situation, and measures changes in that condition or situation over time. Indicators facilitate a close observation about the results of initiatives or actions, and help to simplify the presentation of complex situations" (Sudmeier-Rieux and Ash, 2009:22).

Thus indicators can be qualitative or quantitative expressing different types of complementary dimensions about the situation of interest. Results indicators, measure whether tangible results are being achieved (e.g. new roads have mitigation measures). Progress indicators convey the state of a process (e.g., stakeholder dialogue, capacity building training).The difference between the two may be time dependent (i.e. a capacity building training workshop on landslide mitigation may lead to attitude changes among participants and a process toward new measures may be undertaken. Real progress resulting in new measures and implementation mechanisms may take much longer and is dependent on other factors although the impetus may have come from the initial workshop (Sudmeier-Rieux and Ash, 2009).

Composite indicators, such as the resilience indicator developed by this research, is formed when individual indicators are compiled into a single index on the basis of an underlying model.
"*The composite indicator should ideally measure multidimensional concepts which cannot be captured by a single indicator"* (OECD, 2008:13) e.g. education level, household income, gender inequality.

There are of course pros and cons with composite indicators (Barnett et al., 2008).

Advantages of composite indicators:

- summarizing complex multidimensional data for decision-making;
- easier to interpret than a long list of indicators;
- enables complex comparisons in a given context;
- provides for more effective communication for decision-making.

Disadvantages of composite indicators:

- may produce overly simplistic (policy) conclusions;
- may send misleading messages if not based on scientifically sound research or measurement;
- maybe leave out or not properly account for certain types of information as compared to others.

(modified from OECD, 2008)

There are many different ways of constructing indicators, many based on statistical methods and models such as: Multi-variate analysis, principal component analysis, followed by a normalization and statistical methods for weighing the data (OECD, 2008). Another method is through participatory methods: allowing stakeholders to determine the most relevant indicators based on local needs, field knowledge and experience. Well-established participatory tools for developing indicators, ranking, evaluating and comparing them include: wealth ranking, preference ranking, matrix ranking and matrix scoring and participatory numbers (Chambers, 2007; Mayoux and Chambers, 2005). Such methods are well tested and very commonly used among researchers and practitioners studying livelihoods, vulnerability, hazards, natural resource management, etc. This researcher decided that the advantages of composite indicators outweighed the disadvantages and based on a pragmatic approach, opted for a participatory method for developing indicators of resilience. Before detailing the research methodology, the next section will briefly outline the issue of credibility in social science research.

4.6. Credibility in Social Sciences Research

Perhaps the most difficult part of any research and perhaps especially when combining qualitative with quantitative methods, is to ensure that research results are credible and gain acceptance outside the community of practitioners or its "trustworthiness" (Lincoln and Guba, 1985). Baxter and Eyles (1997), human geographers, highlight elements that are necessary for ensuring rigor in qualitative social science research:, *"the most common ways to ensure rigour are the provision of information on the appropriateness of the methodology, the use of multiple methods, information on respondent selection and the presentation of verbatim quotations"* Baxter and Eyles (1997:521). In other words: credibility through appropriate sampling, triangulation; transferability, and conformability.

The authors mention several other strategies for demonstrating rigor:

- quoting participants;
- details of interview practices;
- discussions of the procedures for analysis;
- revisits to respondents, verification by respondents;
- the provision of a rationale for verification (validity) of the findings;
- the use of standardized interview guides;
- attention to the power relations involved in research interviews.

4.6.1. Sampling

Most common sampling strategies for recruiting respondents are random sampling and purposeful sampling, the strategy used most often by qualitative researchers to obtain information rich cases to match research objectives (Patton, 1990). Also referred to as focused sampling (Hakim, 1987), this type of sampling emphasizes specific reasons for selecting subjects to be studied and analyzed. In our case, purposeful sampling was used to ensure representation of most affected households by landslides and was used for all of the rural study areas.

In purposeful sampling, *"sample size is determined largely by the need to involve as many experiences as possible in the development of a conceptual framework/theory. Recruitment then often occurs until 'redundancy' or 'saturation'; that is, until no new themes or constructs emerge. Thus credibility need not be threatened by low sample sizes. Yet there is still a requirement for qualitative researchers to be mindful of self selection 'biases' which may come from certain strategies like snowball-sampling. While bias maybe used to advantage, the skewing of sample characteristics and types of questions answered and not answered needs to be recognized and 'stratified purposeful sampling' is considered useful in ensuring that all sub-groups within a research setting are given a voice so that comparisons can be used to construct commonalities and differences in interpretations across groups"* Baxter and Eyles (1997:520).

Participatory approaches are very conducive to reasonably accurate purposeful sampling particularly where people meet regularly or if the location is small enough to entice enough people to participate, thus representing all relevant interest categories.

" Although it may be difficult to control who turns up to participatory meetings to 'participate', in many cases it is possible to do reasonably accurate purposeful sampling…. Where appropriate groups can be convened, or random participation groups divided into small discussion subgroups it is possible to obtain reliable aggregated quantitative and qualitative information" (Mayoux and Chambers, 2005:274).

4.6.2. Triangulation

Triangulation refers to the use of multiple methods that complement each other and provide validation of findings. These can be both qualitative, quantitative or combination of both. Triangulation is one of the most important features of rigorous case studies, as the same issue or community is studied from different angles and perspectives.

" Triangulation is one of the most powerful techniques for strengthening credibility. It is based on convergence: when multiple sources provide similar findings their credibility is considerably strengthened" Baxter and Eyles (1997: 518). Hakim (1987) refers to triangulation as a common sense approach to obtaining more comprehensive, valid research results for social science research, and uses the term multiple triangulation : referring not only to multiple sources of data but also multiple researchers involved in the research project .

4.6.3. Other principles for credibility in social sciences research:

- **Transferability** is also known as generalizability or external validity. In other words, research methods and tools used in one context should be transferable to another research context even if the findings differ considerably;
- **Dependability** concerns documenting the research context, or "the consistency with which the same constructs may be matched with the same phenomena over space and time" (LeCompte and Goetz 1982 as quoted by Baxter and Eyles,1997:519);
- **Confirmability** " the degree to which findings are determined by the respondents and conditions of the inquiry and not by the biases, motivations, interests or perspectives of the inquirer. (Lincoln and Guba 1985, as quoted by Baxter and Eyles,1997).

Mayoux and Chambers (2005) argue that participatory research does meet all the above requirements for trustworthy, credible research and they add to the list of research practices that add credibility:

- **Pilot testing:** extended preliminary investigations, investing resources and taking time to identify commonalities with broad validity between types of people and between communities;

  " the process is much more than taking a method, equivalent to a questionnaire, off-the-shelf, and testing it. It is inventing and: for the methods themselves, trying them out, modifying them, and tailoring them to the purpose, people and conditions. With careful and sensitive pilot testing and training, many if not most of the problems associated with participatory methods can be addressed. In particular, trade-offs can be judged and negotiated" (Mayoux and Chambers, 2005:274).

- **Triangulation of findings with participants** through well facilitated participatory research enabling a more systematic discussion of priorities and trade-offs, cross checking with many individuals rather than imposing an external interpretation; however crosschecking information must be closely observed, so that particular groups are not dominating the discussion and adding their own bias.

" in questionnaire surveys this challenge [credibility] is mainly faced at the data analysis stage where all individual views are aggregated and differences, discrepancies and trade-offs are externally evaluated. In participatory methods at least part of this analysis and filtering takes place during the data collection phase itself as part of the commitment to immediate feedback to participants" (Mayoux and Chambers, 2005:275).

Methods used for during the course of this study and measures taken to ensure credibility will be discussed in the following section.

4.7. Methods used in this study

Based on the above principles, the methodological approach that evolved over the course of this research is summarized in Figure 42. It roughly follows three first steps of the CBDRR methodology, consistent with participatory research:

1. Selecting the community;
2. Rapport building and understanding the community;
3. Participatory disaster risk assessment;

The following three steps of CBDRR, go much further to actually establishing a disaster risk management system, were beyond the scope of this study.

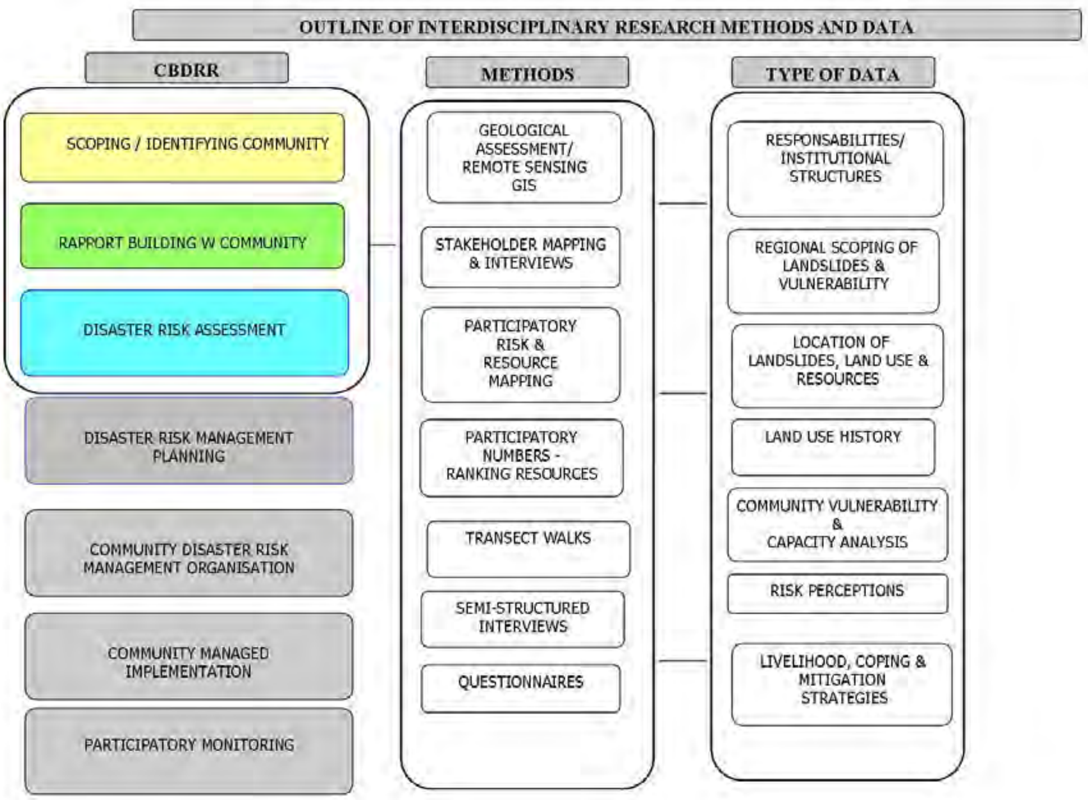


Figure 42. Outline of interdisciplinary research methods and data used for this study based on the CBDRR steps.

A combination of qualitative and quantitative methods were used to develop six case studies: four of landslide affected communities and two flood affected communities (Figure 43). Purposeful sampling was used in the landslide affected communities as our goal was to sample most affected households by landslides as well as less-affected households. For all landslide-affected villages, 45-50% of all households were sampled. For the flood-affected communities, a mix between purposeful and random sampling was used in these densely populated urban neighborhoods (Dharan and Punarbas). Most affected neighborhoods were chosen for the study but only every fifth household was selected for the household survey. Thus these surveys do not represent Dharan and Punarbas, but most affected communities. Quantitative methods (geological assessments, risk assessments, household questionnaires) were used for obtaining data on landslides, household demographics, economics, and risk. Qualitative methods (participatory risk and resource mapping, semi structured interviews, focus group discussions, and stakeholder mapping and interviews) were used for obtaining data on land use history, risk perceptions, community vulnerability and capacities, livelihood coping and mitigation strategies, relations between groups and community and for understanding responsibilities for risk mitigation. These methods led to a number of outputs which are described in more detail in the results chapter. Case studies were based on data collected through participatory risk maps, geologist's risk maps, composite risk map, semi-structured interviews and questionnaires. Other outputs include a typology of coping strategies, guidance matrices for assessing vulnerability and resilience indicators, participatory risk maps, geologists' risk maps and vulnerability- and resilience maps.

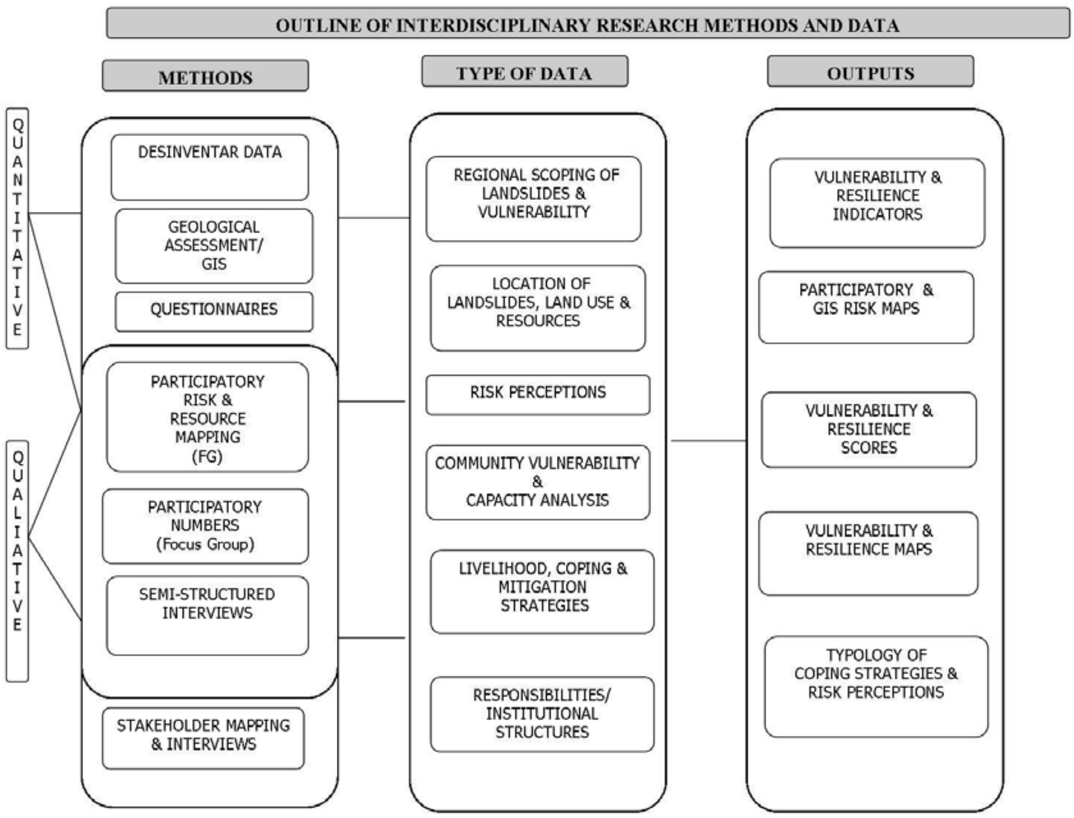


Figure 43. Outline of interdisciplinary research methods and data used for this study.

Table 16. details the methods for each research question and results. Research questions (section 1.3 and 1.4) in the introduction are intended to verify our research hypotheses, the methods thus are the best possible way of gathering data for each research question.

Methodology and expected results		
Research questions (General and specific)	**Methods**	**Results (Outputs)**
1.What is resilience of mountain communities to landslides?		Methodological guidance
2.What are factors of resilience versus vulnerability and capacities? 3. Is it possible to measure resilience and vulnerability?	i. Literature review ii. Participatory numbers	i. Theoretical critique of resilience ii. Community based risk index iii. Community based capacity and resilience index iv. Guidance matrices for vulnerability and resilience indicators
4.What are causal factors of landslide risk for mountain communities in Eastern Nepal?		Case studies
i.Who is being impacted by landslides?	i. District scale using DesInventar data base ii. Village scale based on household survey data	i. Mapping of landslide hotspots ii. Vulnerability indicators iii. Vulnerability maps
ii.How are people impacted by landslides?	i. Regional scale estimates of losses based on DesInventar ii. Case studies: o Geological assessments, risk assessments o Village scale losses based on questionnaire data and participatory risk mapping o Venn diagram - resources and livelihood strategy mapping o Participatory numbers for ranking livelihood strategies	i. Physical risk maps, composite risk maps and land use maps ii. History of landslides for each case study area iii. Type and extent of damage loss iv. Impact on livelihoods
iii.How do households perceive landslide risk?	i.Semi-structured interviews ii. focus group discussions	i.Landslide risk perceptions are compared to other “livelihood concerns”
iv.What are coping strategies to landslides?	i.Venn diagram - resources and livelihood strategy mapping. ii.Participatory numbers for ranking strategies iii. Household surveys	i.Typology of coping strategies. ii.Resilience indicators iii. Resilience maps
v.What is being done by households, communities and authorities to mitigate landslides?	i.Semi-structured interviews ii. Focus group discussions	i. Typology of strategies used by households to prevent and respond to landslides ii. Mapping responsibilities for landslide mitigation

Table 16. Methodology and expected results of this study.

4.7.1. Quantitative methods:

4.7.1.1. Geological assessment **(Dubois, Breguet, Jaquet, Jaboyedoff, Derron, Devkota)**

As this step was conducted by our team's geologists over a period of three years, their method will be briefly described. In general, the assessment began by obtaining detailed geological maps, topographic maps and high-resolution satellite images whenever possible from Google Earth, if not satellite images were purchased. This was the case for Dharan (2009), Sabra (2009) and parts of Dolakha district (2010). GIS shapefiles were purchased with contour lines for most of the sites studied, from which the geology Masters students created a Digital Elevation Model (DEM) (10m). J. Dubois and A. Breguet vectorised contour lines for Katahare and Upper Sardu (Dharan), from which they created a DEM (10m). We therefore have a DEM for each study site.

Extensive photos were taken of landslides and tension cracks, in combination with noting GPS points. This was often conducted based on information from the population, who also provided accounts of past landslide activity and tension cracks. Several senior researchers (Prof. M. Jaboyedoff and Dr. M-H Derron) from UNIL-IGAR came to the field to assess all the landslides in our case study areas with support from Nepali geologist Mr. S. Devkota. The geological assessment resulted in a number of so-called phenomenon (or event) maps, detailing the landslides (soil type, volume, type of failure, triggering mechanisms) as well as risk assessments for all sites studied to be described in the next section. These assessments were the main topic of A. Brequet and J. Dubois' Master's thesis (UNIL-IGAR) in Geology: *Cartographie du risque lié aux glissements de terrain à l'aide de techniques numériques et d'analyses de terrain. Etudes de cas au Pakistan et au Népal* (2009) ; and S. Jaquet's Masters thesis in Environmental Studies (UNIL-IGAR) : *Forest cover trends and landslides occurrence in selected areas, Dolakha District, Central Nepal (2011).*

4.7.1.2. Risk assessments **(J. Dubois, A. Breguet, S. Jaquet, K. Sudmeier-Rieux, M. Jaboyedoff, M-H Derron)**

Risk assessments are the UNIL-IGAR 'specialty' following a very precise methodology. Most risk assessments are carried out in areas with ample data on both the landslides and the population or elements at risk. Due to the much lower data availability in Nepal (and Pakistan), a simplified risk assessment methodology was first developed by J. Dubois and A. Breguet, and later modified by S. Jaquet. There are several methodologies for assessing risk. One of the most commonly used is that established by Einstein (1988) who recommended starting with "event maps", depicting the geometry and mechanism of slope failure, followed by "hazard maps", which depicts the event as well as the expected probability and return time of the event.

- **Geological risk assessment**

For iterations of the risk methodology, risk to buildings was calculated based on the standard equation of risk used by geologists:

$$R = H \times V \times E \times W$$

For the first iteration of risk (Dubois and Breguet, 2009) the main consideration was to adapt the standard method used in the Alps for assessing landslide risk to a more simplified method more appropriate for a data poor environment such as Nepal (Heinimann, 1999; Keiler et al. 2006) (Table 17).
The above equation was modified and replaced by a “relative risk method” based on:

- The potential of destruction (Pd) , is an approximation of the event intensity and the estimated recurrence interval from 0-4, 0 being without danger and 4 being the most intense. It is determined by the type of landslide (active, dormant), speed of movement, direction, historic data of the landslide and given a value (0-4);
- Vulnerability (vulnerability to the phenomenon) (Vp) is estimated according to the solidity of the construction compared to the type of danger: 1 is the least solid, meaning that the building would be completely destroyed during the event. (Dubois and Breguet, 2009); resulting in:

$$Rr = Pd\ x\ Vp$$

Risk is thus the multiplication of this destruction potential by the vulnerability and the number of inhabitants. For example, a house inhabited by five people, located in an active landslide zone has a maximal destruction potential of 4. The house is considered to be completely destroyed, thus the vulnerability is 1. The risk is 4 x 1 x 5 = 20.
Figure 44. describes the relative risk estimates as they relate to classifications from very low risk to high risk. This classification can be linked to a relative estimate of loss of life, with very low risk corresponding to one death every 200 years, medium risk corresponds to one death every 100 years and high risk corresponding to one death every 50 years. We recognize that this classification has its limits, as what may be considered high risk and low risk is highly normative but it is suggested as one way of providing guidance for prioritizing mitigation activities (Dubois and Breguet, 2009).

Color	Estimated relative risk	Time period	Classification
White	<0 to 1 <	>200 years	Very low risk
Yellow	<1 to 10<	100-200 years	Low risk
Orange	<10 to 20<	50-100 years	Medium risk
Red	> 20	<50 years	High risk

Table 17. Estimated relative risk to buildings, (Modified from Dubois and Breguet, 2009)

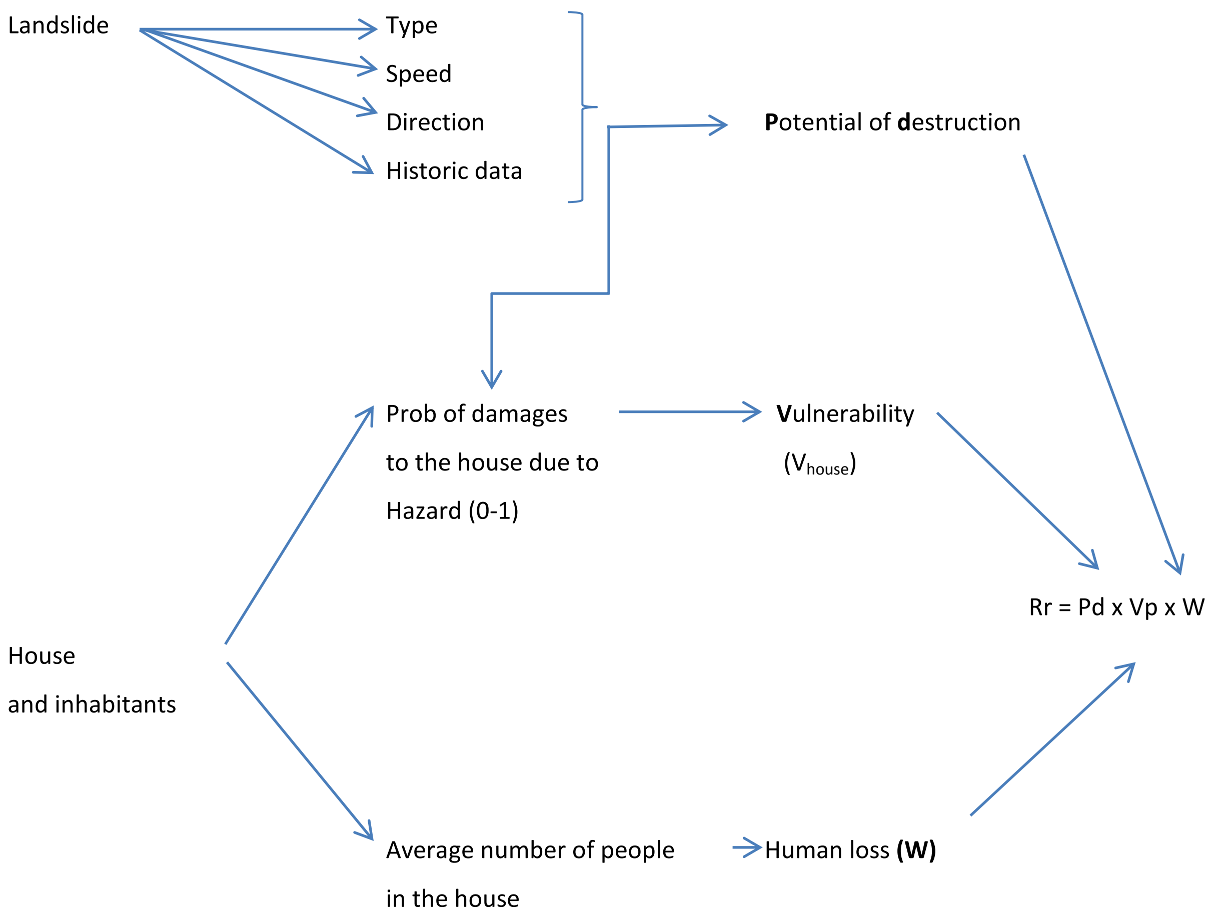


Figure 44. Method for assessing landslide risk, using the "Relative risk" concept (Dubois and Breguet, 2009)

For the second approach to calculating risk, the following method was used (Jaquet, 2011b) (Figure 45).

- H is the hazard, (the probability of hazard occurrence in for a time reference (P); 50 years for hazardous event and 100 years for less hazardous event), expressed as:

$$P = 1 - e^{-n/T}$$

T is the return time of the hazard event and *n* the reference time.

- V is the vulnerability, (the degree of loss in case of a hazard event)
- E is the exposure (time spent in house and likelihood of escaping a hazard event)
- W is the number of fatalities or the economic loss (represented as the number of average inhabitants per building)
  (modified from Jaquet, 2011b)

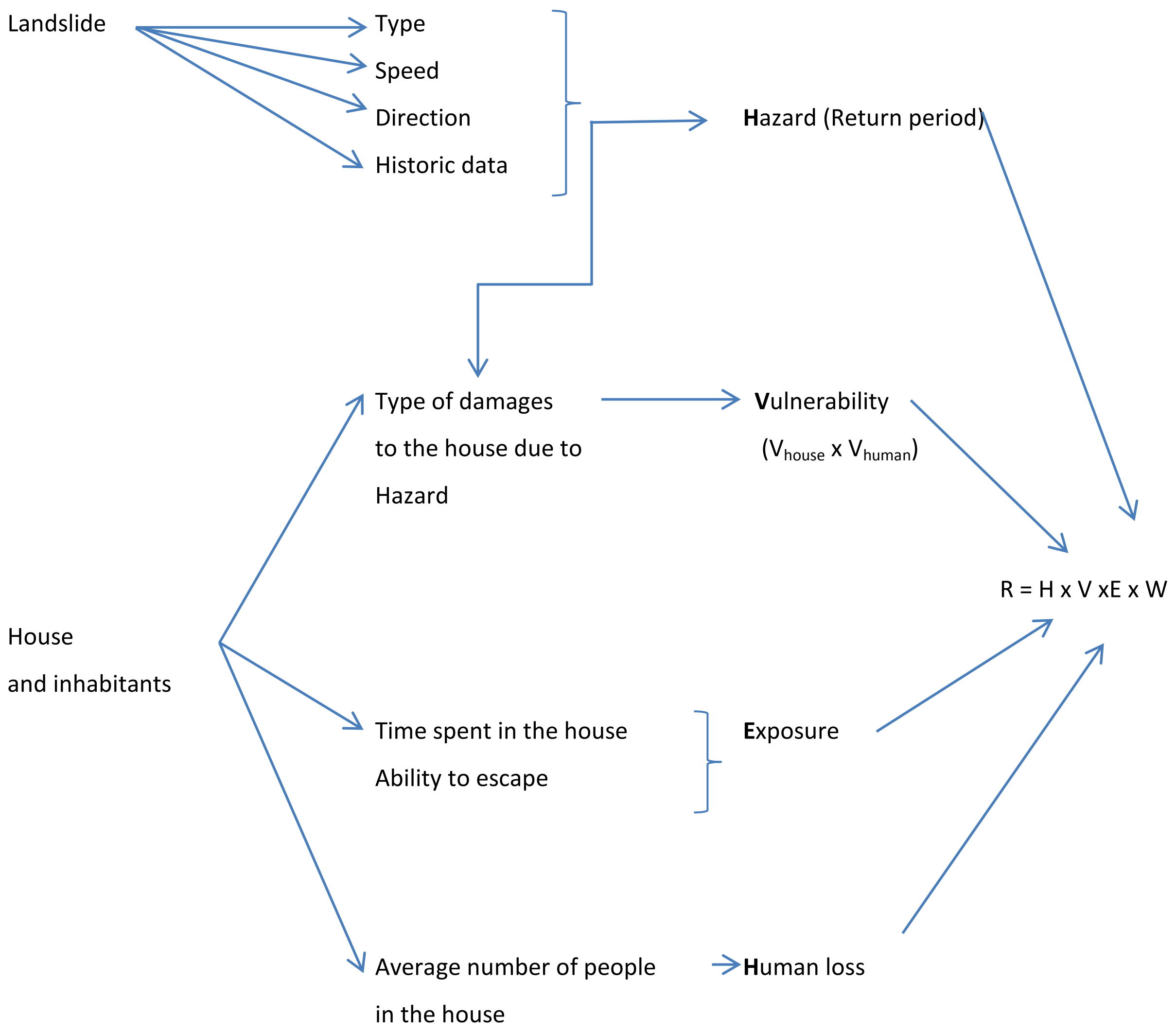


Figure 45. Method for assessing risk to buildings (from Jaquet, 2011b)

Composite risk assessment

The definition of vulnerability as being "the degree of loss in case of a hazard event" is appropriate for a geological assessment of risk but not for understanding the multiple dimensions of risk per the UNISDR definition of vulnerability: *"The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard*" (UNISDR, 2009b). The first definition, or physical vulnerability, does not take into account other aspects of vulnerability such as demographics, economics, or social conditions. In other words, a widow living in a similar physical structure as a younger family will receive the same risk score in the physical risk equation. Thus, an alternative risk calculation is proposed, using data from the household survey on 50 indicators that determine vulnerability, divided into five categories: economic, environmental, social, natural, human. How these indicators were developed will be given in more detail in the next section.

Data for each of the 50 vulnerability indicators were collected from the household survey and semi-structured interviews, which covered each aspect of vulnerability based on the SLA and the five resources or capitals (Economic, Environmental, Natural, Human), replacing vulnerability in the more classical equations of risk mentioned above.

$$Rcomp = H \times Vcomp\,\{Econ, Env, Soc, Nat, Hum) \times E \times W$$

Data were collected on 50 indicators of vulnerability; some of the data were quantitative, such as the amount of land available, or number of consumer goods and some were qualitative. Each variable was assigned a value from 0 to 3, creating an indicator value or score. This score does not have a unit but can be considered an index figure, only useful as a relative figure for comparison. The other data from the risk composite equation were the same as those used for the physical risk calculations. This method is further described by Figure 46.

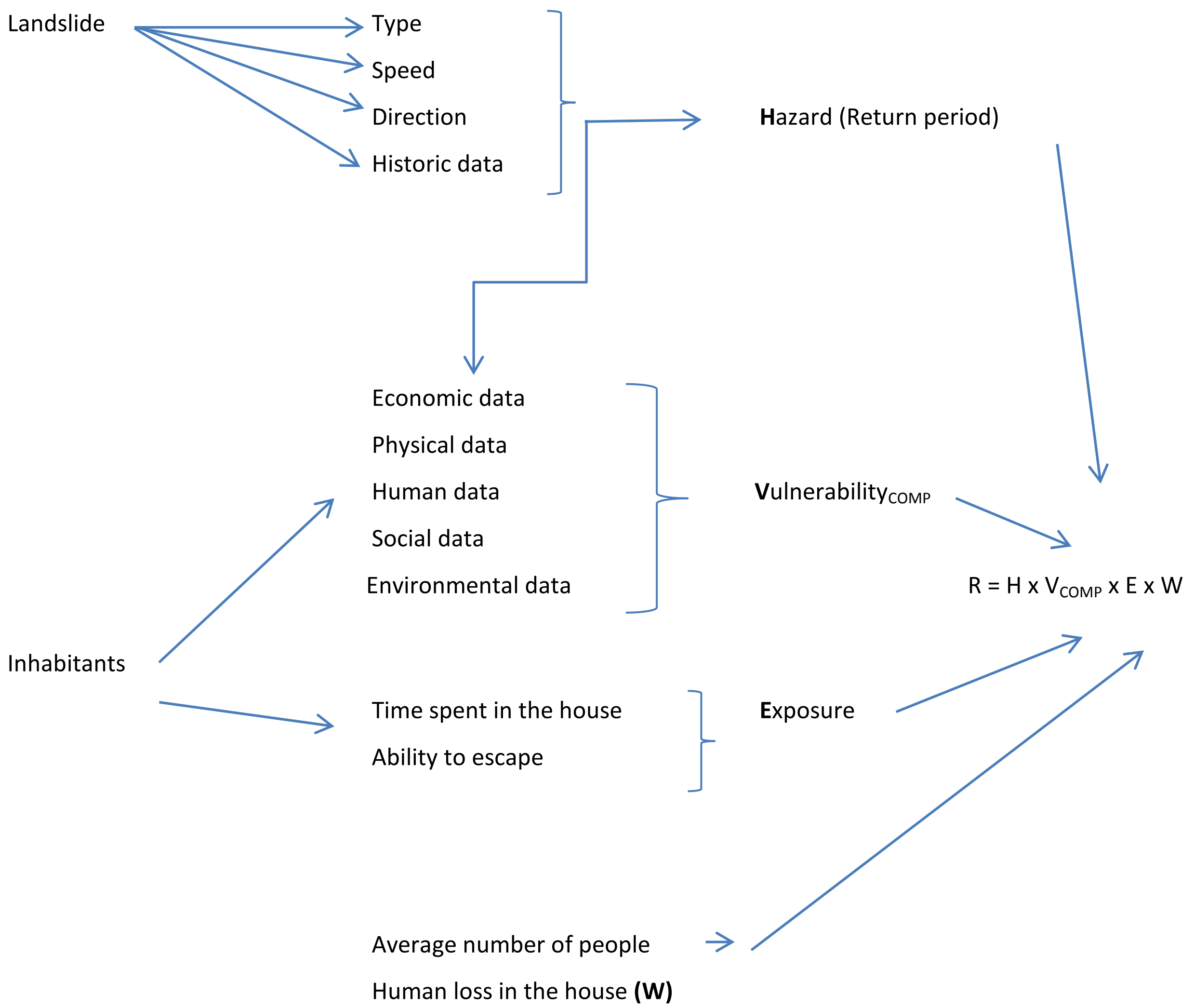


Figure 46. Composite risk calculation (modified from Jaquet, 2011b)

4.7.1.2. Household surveys **(Sudmeier-Rieux for the rural and Basyal for the urban areas)**

The choice of using household surveys was made for several reasons: the principal reason was to enable standardized data collection in order to develop the vulnerability and resilience indicators and ensure standardized comparison between communities in landslide affected areas as well as flood affected areas. The survey instrument was first developed for the Pakistan study in 2006-2007. It was tested again in 2008 in Nepal and again modified with input from G.K. Basyal (then with ITC, Netherlands) with suggestions from our Nepali translator and sociologist M. Dahal (then with IUCN) and other staff at IUCN. For the 2009-2011 study, two versions of the questionnaire were developed: one for the rural areas, which were surveyed by this researcher and one for the urban areas, surveyed by G.K. Basyal for his Master's project with ITC. Considerable effort went into pilot testing and contextualizing the survey instrument, which consists mainly of open questions in six different sections:

- demographics, including information on migration and origin;
- physical condition of the household and access to public infrastructure
- socio-economic status, including a number of proxy questions on household income, which was considered too sensitive to ask directly;;
- exposure: experience with and losses due to landslides;
- institutional social and health indicators: including access to information membership and social organizations, questions on social cohesion and household priorities and concerns;
- optionally, questions were asked on observations and knowledge about climate change.

Household surveys were conducted using translators, and often used as a guide for other additional interview questions. This is why we also refer to the household surveys as semi-structured interviews as we did not always confined interviews only to the questionnaire. Each household semi-structured interview took between 1 to 1- 1/2 hours. In the rural areas, households were sampled based on the purposeful sampling approach, in order to question to the extent possible all households closest to landslides or rivers, along with other households further away to ensure a mix of higher risk and lower risk households. Whenever possible, households considered vulnerable (i.e. female-headed) were surveyed, along with 'better off' households. For the urban areas, Mr. Basyal selected most affected neighborhoods in Dharan and Punarbas, and within these neighborhoods conducted stratified sampling by questioning every fifth household. Three affected neighborhoods were surveyed in Dharan, of which the community by Seuti Khola was interviewed by this researcher and translator Ms. I. Rai. Each household in landslide affected areas was marked using a GPS, thus each household had its own GPS point enabling identification in GIS databases and maps. The number of households surveyed depended on the size of the community, as our goal was to survey between 40 to 50% of all households. This number was achieved for all of the rural communities and in all cases for the last households, saturation was achieved when no new information was being obtained.

At the end of each day, questionnaires and field notes were systematically cross-checked with the translators to ensure that all questionnaires were complete and all information obtained was clear. Data from the questionnaires were entered into an Excel spreadsheet.

4.7.1.3. Indicator development **(Sudmeier-Rieux)**

In order to test our research hypotheses and develop a guidance tool for comparing levels of vulnerability and resilience between communities, household data were used for developing vulnerability and resilience indicators.

Indicators were developed based on a literature review, three years of field observations and testing of indicators with local populations and local experts. Based on this experience, they are relevant for describing vulnerability and resilience within the context of the Middle Hills of Nepal. There are 50 indicators of vulnerability, divided into the five categories of resources as outlined in the sustainable livelihoods approach. There are 40 indicators of resilience also divided into the same five categories.

- **Vulnerability indicators**

Values for each indicator were obtained from the household survey questionnaires. Each indicator received a score from 0 to 3, zero being no vulnerability to three being highest vulnerability (Figure 47, Figure 48, Figure 49). The **maximum vulnerability score possible for each household is thus 150**. Often survey respondents ranked indicators themselves, but using a qualitative scale, such as good, medium, bad, i.e. for sanitation, electricity, access to schools, roads, health care, drinking water. Most of the time, this ranking was conducted as a comparative ranking within the community, i.e., number of livestock, consumer durables, income diversity, food stocks, population density, soil productivity, etc. For this type of ranking and in order to avoid bias, a template was developed with our Nepali colleagues to establish weights for assets in order to determine high, medium, low. For example, templates were developed to estimate livestock values, consumer durables, education levels and household status with weights assigned to livestock depending on their value, i.e., buffaloes, ox, cows, pigs (only certain ethnic groups) were assigned higher values than goats and chicken. TVs, satellite dishes, fixed telephones were assigned higher values than radios or cassette players. In contrast to the VCI method developed by (Moench & Dixit, 2007). This researcher decided not to assign weights to each indicator, i.e. each indicator has equal weight. The household status indicator differs somewhat as it is a composite of four sub indicators: health status and age, ethnic group, female headed households, number of dependents. These indicators were developed based on field observations for the specific context of Central and Eastern Nepal, however they are intended as guidance indicators that served our purpose well. For other contexts they would need to be modified accordingly.

ID/GPS	Food stocks	Diverse income	Livestock	Remittances	Savings	Total
01	1.0	1.0	1.0	0.0	0.0	6.0
02	2.0	2.0	1.0	0.0	0.0	9.0
03	1.0	1.0	1.0	0.0	0.0	6.0
04	2.0	1.0	1.0	0.0	0.0	7.0
05	2.0	1.0	1.0	1.0	0.0	9.0
06	2.0	2.0	1.0	0.0	0.0	8.0
07	2.0	3.0	1.0	0.0	2.0	12.0
08	1.0	2.0	1.0	0.0	0.0	8.0
09	2.0	2.0	1.0	0.0	1.0	10.0
10	2.0	1.0	1.0	0.0	1.0	9.0
11	2.0	1.0	1.0	0.0	0.0	6.0
12	1.0	1.0	1.0	0.0	0.0	7.0
13	2.0	3.0	1.0	0.0	0.0	10.0

Figure 47. Example of spreadsheet for households in Thang thang community related to their economic vulnerability

ID/GPS	Occupation	Economic	Physical	Human	Social	Environmental	Total
01	Farm/Labr	20.0	19.0	17.0	23.0	20.0	99.0
02	Farm/Labr	17.0	21.0	18.0	23.0	20.0	99.0
03	Farm/Labr	21.0	22.0	19.0	27.0	20.0	109.0
04	Farmer	19.0	23.0	21.0	23.0	20.0	106.0
05	Farm/Labr	17.0	20.0	17.0	25.0	20.0	97.0
06	Farm/Labr	19.0	24.0	20.0	25.0	20.0	108.0
07	Carpenter	16.0	15.0	17.0	25.0	20.0	93.0
08	Farmer	18.0	20.0	20.0	25.0	20.0	106.0
09	Farm/Labr	17.0	16.0	17.0	23.0	20.0	106.0
10	Farm/Labr	22.0	18.0	19.0	27.0	20.0	106.0
11	Farmer	23.0	21.0	21.0	21.0	20.0	114.0
12	Farm/Labr	21.0	21.0	23.0	29.0	20.0	93.0
13	Goldsmith	14.0	16.0	16.0	27.0	0.0	102.0

Figure 48. Thang thang household spread sheet for composite vulnerability score

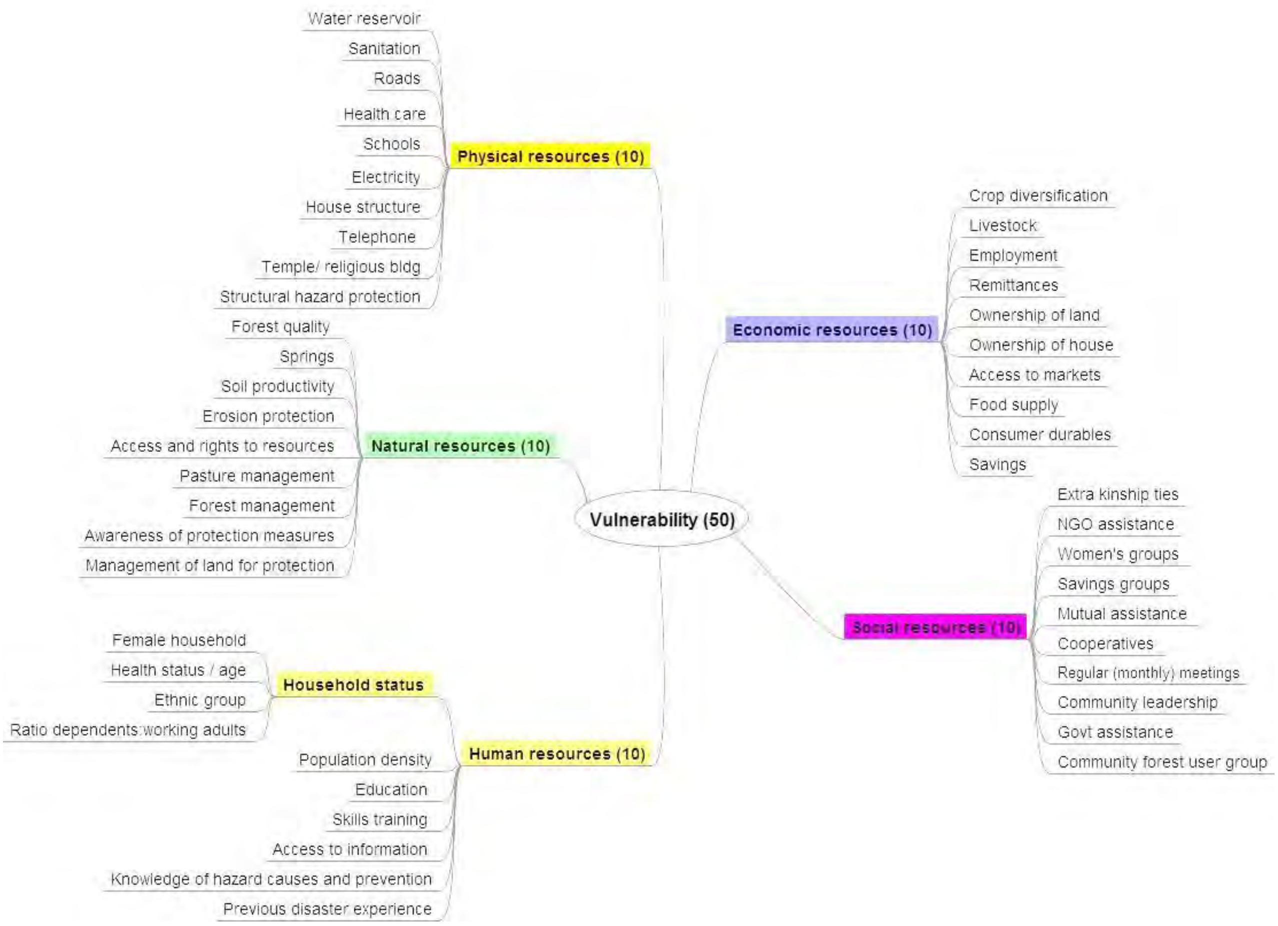


Figure 49. Vulnerability indicators

As for the vulnerability indicators each resilience indicator has the same weight. Each has been assigned a score from 0 to 3 with zero being the minimum and three the maximum. **The maximum resilience score possible for each household is thus 120.** In spite of our theoretical conviction that resilience is not the opposite of vulnerability, a majority of indicators are actually the exact opposite, except for 8 indicators (Figure 50, Figure 51, Figure 52).

An earlier set of resilience indicators was presented to one community group in Khariswara (see Section 5.1.2) to test their relevance among community members. Based on this field testing, a final set of indicators was developed and presented in Figure 52. Certainly more field testing would be useful for further validating these resilience indicators.

ID/GPS	Food stocks	Diverse income	Livestock	Remittances	Savings	Crop diversity	Consumer durables	Total
01	1.0	1.0	1.0	0.0	0.0	1.0	2.0	6.0
02	2.0	2.0	1.0	0.0	0.0	1.0	3.0	9.0
03	1.0	1.0	1.0	0.0	0.0	1.0	2.0	6.0
04	2.0	1.0	1.0	0.0	0.0	1.0	2.0	7.0
05	2.0	1.0	1.0	1.0	0.0	1.0	3.0	9.0
06	2.0	2.0	1.0	0.0	0.0	1.0	2.0	8.0
07	2.0	3.0	1.0	0.0	2.0	1.0	3.0	12.0
08	1.0	2.0	1.0	0.0	0.0	1.0	3.0	8.0
09	2.0	2.0	1.0	0.0	1.0	1.0	3.0	10.0
10	2.0	1.0	1.0	0.0	1.0	1.0	3.0	9.0
11	2.0	1.0	1.0	0.0	0.0	1.0	1.0	6.0
12	1.0	1.0	1.0	0.0	0.0	1.0	3.0	7.0
13	2.0	3.0	1.0	0.0	0.0	1.0	3.0	10.0

Figure 50. Example of spreadsheet for households in Thang thang community related to their economic resilience

ID/GPS	Occupation	Economic	Physical	Human	Social	Environmental	Total
01	Farm/Labr	6.0	7.0	11.0	8.0	6.0	38.0
02	Farm/Labr	9.0	7.0	11.0	10.0	6.0	43.0
03	Farm/Labr	6.0	4.0	12.0	8.0	6.0	36.0
04	Farmer	7.0	4.0	9.0	10.0	6.0	36.0
05	Farm/Labr	9.0	7.0	11.0	10.0	6.0	43.0
06	Farm/Labr	8.0	4.0	9.0	8.0	6.0	35.0
07	Carpenter	12.0	7.0	11.0	8.0	6.0	44.0
08	Farmer	8.0	4.0	9.0	8.0	6.0	35.0
09	Farm/Labr	10.0	7.0	9.0	8.0	6.0	40.0
10	Farm/Labr	9.0	7.0	8.0	6.0	6.0	36.0
11	Farmer	6.0	4.0	8.0	8.0	6.0	32.0
12	Farm/Labr	7.0	4.0	9.0	6.0	6.0	32.0
13	Goldsmith	10.0	4.0	9.0	8.0	6.0	37.0

Figure 51. Thang thang household spread sheet for composite resilience score.

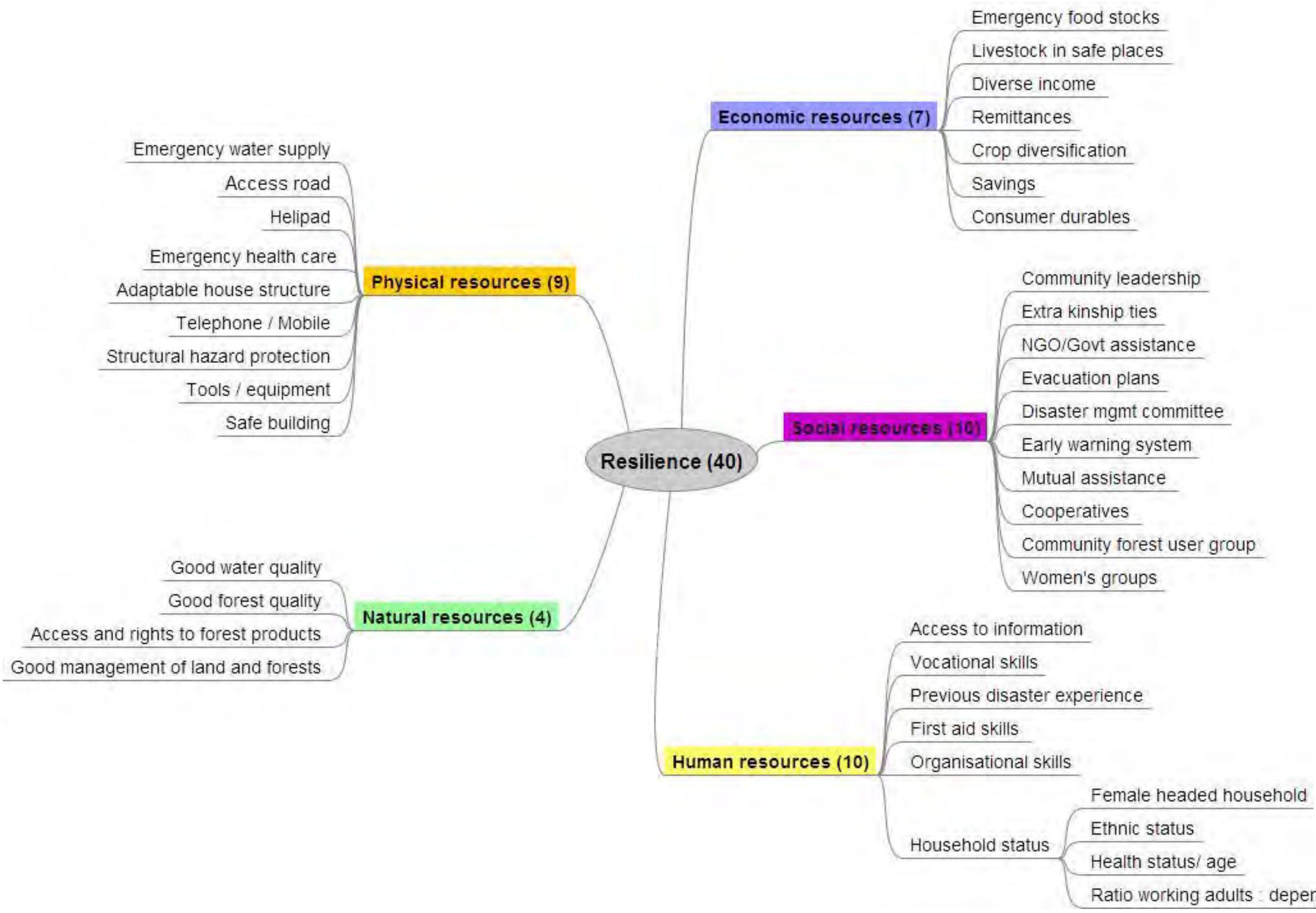


Figure 52. Resilience indicators

The above spreadsheets for Thang thang village are thus compared with similar spreadsheets for the other villages, providing a snapshot in time of a number of resilience and vulnerability indicators. Results are credible as they parallel other socio-economic data obtained from the household survey (chapter 6). This method provides us with a composite score, or an index, which is useful for comparing between households and villages. The scores do not have a unit per se but are a relative index. As mentioned above, there are certainly advantages and disadvantages to developing quantitative indicators for measuring vulnerability and resilience. The advantage of this method is its cost-effectiveness and flexibility, using both qualitative and quantitative data. It is also useful as a guidance tool for directing NGO or government interventions. The disadvantage is that it is a snapshot; this is not a problem if we consider that we define vulnerability to be a set of characteristics of a population. However, this method does not capture the dynamic nature of resilience or its temporality. We thus conclude this section on indicators and move to the next section on qualitative methods.

4.7.2. Qualitative methods **(Sudmeier-Rieux)**

Qualitative participatory methods were heavily relied upon for the case studies and for complementing information needed for developing the geologists risk maps and composite risk maps. Main qualitative methods used: exploratory interviews for the first preliminary surveys, transect walks were essential to understanding land use and land use history, participatory risk mapping, which became one of the most important elements of the case studies and social resources mapping which evolved, using Venn diagrams to understand risk perceptions, coping strategies, and community concerns and priorities. In-depth interviews with “key informants” , mainly local government officials and other NGOs were useful for obtaining other perspectives on the communities, their risk situation and mitigation possibilities.

4.7.2.1. Participatory risk mapping

Usually after the first introductory discussion with the community the first exercise conducted in each of the landslide affected communities was participatory risk mapping (Figure 53). It was a good way to get to know the community, what the community considered to be most important for them and for the community to get to know us. Most often, we only brought large (A3) blank sheets of paper, and colored pencils. Sometimes community members wanted to see our topographic maps and use them to start their maps but most of the time they relied on their own knowledge of the community. The participatory risk mapping exercise usually started with a group of 10 to 12 people, mixed men and women, young and old, but in the end, the most educated male was usually selected or self-selected to draw the map with one or two male assistants. If the male was younger, they asked elder males to assist him in completing or correcting the map. Before the mapping session was over, we requested that other community members especially women, look at the map and suggest additions or corrections. The women's suggestions were often discussed and usually accepted by the map makers. The first map was made in 2008 in Katahare, the same map was brought to the community again in 2009 and validated. The second and third maps were made in October 2010 in Khariswara and Thang thang, but this time we asked the community to highlight houses most at risk in red, less at risk in orange and

Figure 53. Left: map making in Thang thang, illiterate community, October, 2010: Right: map making in Katahare, October, 2008

not at risk in yellow. Each map took approximately 3 hours to be developed. Unfortunately, poor weather did not enable enough time for a community risk map to be developed in Sabra.

4.7.2.2. Social resources mapping

This was an exercise that evolved over time and typifies the grounded theory principles of both an iterative approach based on field observations, and study of theoretical concepts. The original idea was to adapt the Venn diagram exercise (Chambers, 2007), used for mapping stakeholders and relationships between stakeholders to better understand community resources and links between them. Another idea that evolved was to map how communities conceptualize resilience by asking them to map resources needed in an emergency situation, as one cannot realistically ask communities directly to map resilience. As these reflections came later in PhD thesis process, this exercise took place in the last two communities for which case studies were developed (i.e. Khariswara and Thang Thang). The first exercise on community resources was conducted in Khariswara with separate women's and men's groups (Figure 54). Women were asked to name those resources most important to their community. These factors were noted on different colored post-its and placed randomly on a large blank A3 sheet of paper. The women were then each given four small post-its and asked to vote on the four most important resources and finally asked to group the factors and name the groups. The same was done with the men's groups, whose exercise turned out more to be a planning session for how to improve village development.

The following day, the same groups were convened together and the women presented their map to the men and vice versa. Often an interesting discussion ensued, usually with the men and women's groups finding the other group's exercise interesting and complementary. Some discrepancies were noted between the two groups' perspectives and a compromise solution was found. On the last day, the 40 indicators of resilience were presented to a group on 40 different post-its grouped according to resource type. Feedback received from the several risk and social resources mapping exercises was that these had been useful for the community to better understand their resources and how to better plan ahead.

Figure 54. Khariswara social mapping exercises, October, 2010

In Thang Thang, as the community is illiterate, the exercise was modified somewhat. Thanks to preliminary investigations, we knew that the situation in this community was sensitive due to a power conflict with the neighboring community and local government, VDC. We therefore declined assistance of a local government official from a higher caste who had offered to accompany us. As suspected, community members also did not wish to invite any local government officials to our discussions with them.

Another modification of the social mapping exercise was to draw symbols of key words as identified by the community, to facilitate communications. Both the women and men's groups in Thang Thang then grouped the factors that they had identified and named them, just as well as in well-educated Khariswara. In addition, the men's group conducted an exercise identifying those resources needed in case of emergency, as a proxy for identifying indicators of resilience. The group discussion that ensued ended up being especially rewarding for both the community and researchers, as many community members told us that this was the first time they had discussed matters together related to their community organization, landslide risk and the problems associated with their irrigation canal and their problematic community forest user group. The exercise linking social resources made them realize for the first time that many of their food security problems were linked to no access to land and domination by the neighboring high caste community.

Figure 55. Social mapping exercises in Thang Thang, October 2010.

As most of our visits took place in September-October, during the harvest season, we were very cognizant of the limited time available for discussions. In fact, after three days of continuous visits, we felt that we had reached saturation in terms of information received and nearing the end of the warm welcome we had received in every community. It is very possible that similar visits undertaken during the winter months could be extended for longer periods of time, although it is not clear how much more additional information would be obtained.

4.7.2.3. Focus group discussions

During preliminary investigations, usually focus groups was the first exercise undertaken for the land slide affected communities as well as in Punarbas. It is also a near mandatory step of the protocol in terms of first steps and usually introductions were made through either our partner NGOs if they already knew the community, or through a local contact made through our partner NGO. The introductory focus group discussions are a way of introducing the researcher to the community and vice versa, explaining the purpose of the research, and clearly defining expectations. We always clarified our role as being researchers with limited ability to bring resources to the community. The only promise we made was to write up our findings in research reports and send these to all concerned governments agencies, which we did in all cases and most reports were translated into Nepali.

After preliminary introductions, discussions were held with the community via a translator to obtain a general idea about the landslide situation, land use history, which households and families were most at risk, general ideas about what causes the landslides, what mitigation actions have been undertaken and what responsibilities are taken by local government. Several other focus group discussions were later organized, in Punarbas, Katahare, Khariswara and Thang thang, led by myself via a translator. The most frequent recording method were detailed notes taken by translator, myself and a Nepali speaking third person who was asked to take detailed notes. At the end of the day, notes were combined, typed and cross checked for any errors or omissions. The Punarbas focus group discussion was additionally recorded and transcribed, as for this focus group we did not have a third person for taking notes. As these discussions were intended as a supplement to the household surveys, or to obtain more in-depth knowledge about land use history, risk perceptions and coping strategies, no specific content analysis was undertaken, as would have been the case if focus groups were the only research method.

Figure 56. Punarbas focus group discussions, October 2008 and 2009

4.7.2.4. Transect walks

Transect walks were conducted in every case study location, usually during the first day of each new community we visited. These were always conducted in groups with a self-selected member from the community, usually with an older community members to obtain information on land use, location of scarps and village history. Locally guided walks were especially helpful for improving information used for the risk maps. Usually either starting from the very bottom of village up to the very top, or vice versa and considering an elevation gain between 150-400 m, the transect walks took anywhere from one hour to all morning . Extensive notes were always taken during the walk and later transcribed and cross checked. One challenge with information received during transect walks was that sometimes the information differed depending on the guide. It was especially difficult for people to remember when events occurred. We would sometimes get conflicting stories about when the landslide occurred with 10 to 20 years difference . What often helped is when people situated a landslide event in relation with a well-known family or political event: "*it is true, now I remember that the landslide occurred the same year the King was killed, so that would have been 15 years ago* " (women in Katahare, October, 2009).

Figure 57. Left :Guided transect walk, Thang Thang, landslide scarp October 2010; right: transect walks, Khariswara, collapsed road, October 2010.

4.7.2.5. In-depth interviews with key informants

The last qualitative method used were in-depth interviews with so-called, “key informants” to obtain complementary information and different perspectives on the case study communities, their risk situation, whether development initiatives were being undertaken, responsibilities for risk reduction and issues concerning ethnicity. Whenever possible upon first arriving in a new area, we began by meeting local officials to introduce ourselves and our team, exchange information about the purpose of our study, and learn about the role of local government agencies. The step of meeting officials was also near mandatory and conducted for every research site, except in Sabra, as the district headquarters is located another half a day drive away. Meetings were arranged through our local partner NGOs (either IUCN or NSCFP), without whom such meetings would have been more difficult to arrange. We were able to meet with most officials that we hoped to meet. At the village level, we usually first met with the community leader, when there was one; secondly, the main government official in charge of development issues at the VDC; district level, we met with forest office officials, development officials, and soil conservation officers; at the regional level we manage to meet the official in charge of disasters for Sunsari district, two weeks after the Koshi dam flood disaster. At the national level, in Kathmandu, we interviewed a number of national officials at the Department of Water Induced Disaster Prevention (DWIDP), the Forest Department, Disaster Preparedness network (an umbrella organization for disaster preparedness) and most of the international NGOs working on disasters in Nepal: Oxfam, Action Aid, Practical Action, CARE. This researcher was invited to a national workshop on disaster prevention in April 2010, attended by over 300 national stakeholders in the DRR/CCA field.

Whenever possible, follow-up meetings were arranged with local government officials to explain research findings and discuss our reports. This was especially critical for the Dharan municipality, where flooding is a major concern and there is little to no capacity to mitigate flooding. Poster size Google Earth maps were provided to the municipality as well as a detailed report with flood risk modeling (Figure 58). In many cases, we found that most local government agencies had very basic tools and means for addressing landslide or flood risk. Most did not even have topographic

Figure 58. Left: Presentation of research findings at stakeholder meeting to discuss watershed issues in Dharan, attended by local NGOs, Members of Parliament, and local government officials. Right: at Dharan Municipality with technical staff, October, 2009.

maps, little to no knowledge about causes of landslides or mitigation and very limited knowledge about flooding. The only mitigation measures we observed were the construction of gabion walls after steel wire was provided by the Department of Water Induced Disaster Prevention, regional headquarters but with little technical guidance.

To sum, these in-depth interviews were very useful for better understanding government capabilities and responsibilities for landslide in flood mitigation. We also found that local government officials were very keen for local researchers to study such issues and provide them with any technical expertise. Again, for each studied site, we developed a technical report on the hazard and risk situation, with practical recommendations, almost all translated into Nepali.

4.7.2.6. Summary of research steps

To conclude, steps undertaken for developing each case study are described in Figure 59. Each involved five steps: stakeholder identification, assess hazard & exposure, assess losses, assess vulnerability, resilience and coping capacities, verification of results. For the landslide affected villages, the case studies are intentionally more complete as more emphasis was placed on assessing the hazard, exposure and losses. The first and last step, stakeholder identification and verification of results are essential to obtaining complete information about each case study site

A list of technical reports drafted during the course of our research can be found in Appendix II.

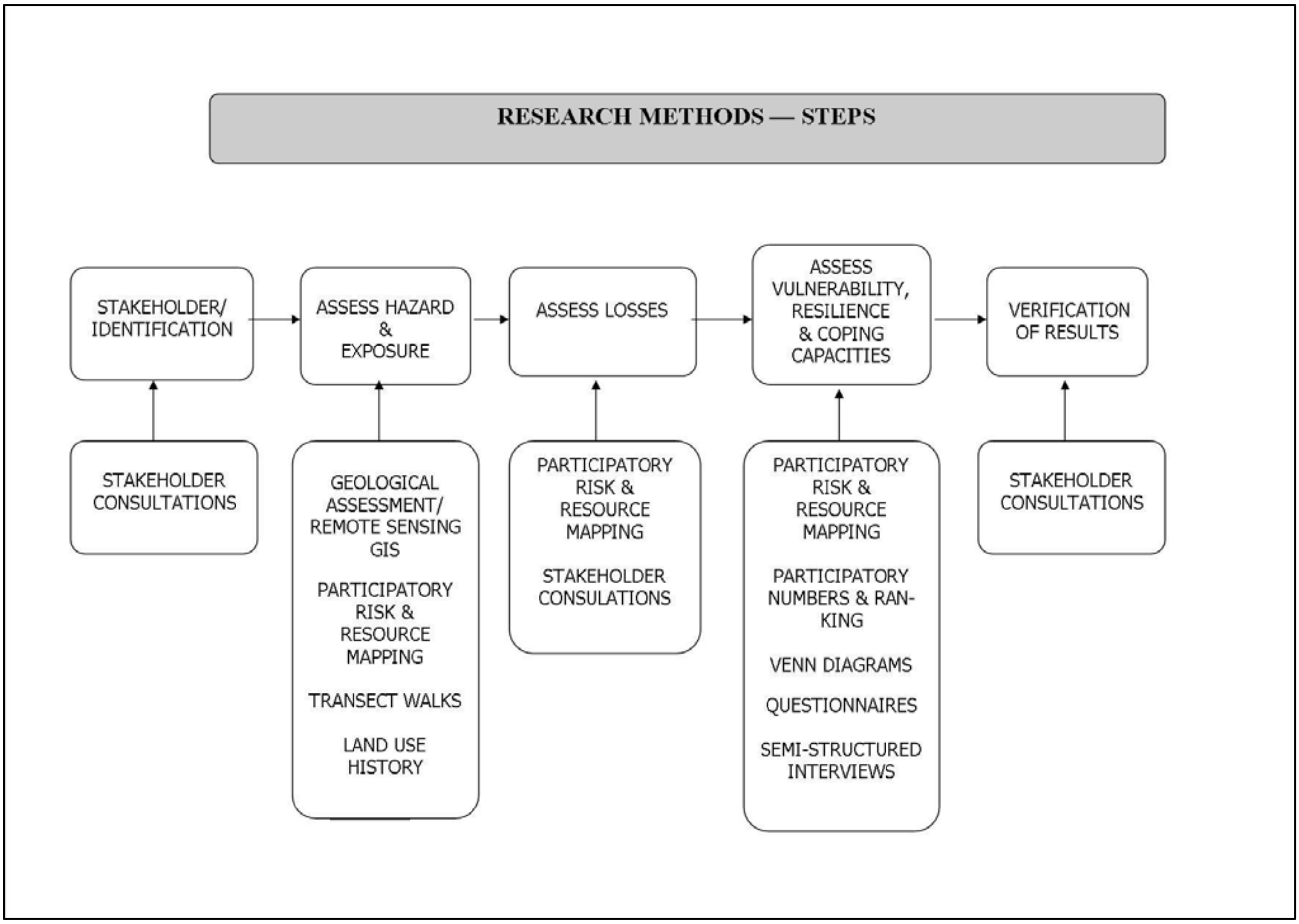


Figure 59. Research method and steps undertaken for each case study site from stakeholder identification to verification of results.

From theory to practice, the next chapter describes the six case studies, followed by a chapter comparing results and analyzing vulnerability and resilience data.

Results: case studies

In order to respond to our research objectives and research questions, results are organized in two chapters. This chapter details the six case studies, four from landslide-affected villages, two from flood-prone areas:

Each case study description will follow the integrated risk model (Figure 21) covering three contexts: environmental, geological and social, followed by the integrated risk assessment:

- Environmental context: land use and land use history;
- Geological context: a description of the geology, assessment of risk and local knowledge;
- Social context: socio-economic conditions, local knowledge, risk perceptions risk and coping strategies;
- Integrated risk assessment: based on maps - participatory risk map, landslide physical risk map, landslide composite risk map.

5.1. Case study I. Khariswara village

Khariswara Village Fact Sheet	Ward 6 Gairimudi VDC 27°37'10.39'' N, 86°06'33.46'' E
Elevation	950-1350 m.a.s.l.
Average annual rainfall	1568 mm
Surveyed population	n=13, ca. 25 persons in focus group discussions
Population size	28 households (4 have out migrated) (ca. 150 persons
Average household size	5.5 persons
Occupations	Farmers, government officials, teachers, priests.
Land use	Mainly rice, vegetables, some millet and fruits.
Average age of household head	42 years
% families with one member abroad	69%
% families receiving remittances	38%
Ethnic group	*Chhettri* (high caste)
Average land holding per household **Average land holding for the VDC**	0.58 ha 0.50 ha
Literate	61%
Average food supply	6.8 months
Average % mobiles	69%
Electricity %	100%
Good sanitation facilities	69%
Average loss due to landslide	3 ha rice fields lost 5 ha converted to rain-fed terracing 1 house cracked
Geology	Talc, laterites Poor soil cohesion Good soil productivity
Risk priorities	Landslide mitigation or relocation; village development: repair road, expand limestone quarry, develop micro hydro station, maintain social harmony.

Table 18. Khariswara fact sheet

Khariswara village	**Ward 6, Gairimudi VDC, Dolakha district,** 27°37'10.39'' N, 86°06'33.46'' E
Surveyed population and methods October, 2010	n=13 surveys and in-depth interviews (50% of village pop.) 3 focus group discussions ca. 25 persons in focus group discussions transect walk risk mapping exercise social mapping resilience indicators mapping Google map satellite images Topographic map 1:10,000

Table 19. Khariswara village, research methods

5.1.1. Overview

Situated in the Middle Hills of Dolakha district (27°37'10.39'' N, 86°06'33.46'' E) at 950-1350 m.a.s.l. in a temperate climate, Khariswara is a so-called "high-caste" (*Chhettri*) community (NDFIN, 2001) (Table 18). The average annual rainfall is 1567.9mm with a maximum 24 hours rainfall of 201mm (Nepal Min. of Hydrology data). With 32 households (of which 4 have out-migrated) and 150 persons, it is a relatively well-off community as compared to the district average landholding, months of food stocks and education levels). The majority of the VDC population is *Tamang*, followed by *Newar* and *Chhettri* (VDC profile, 2010). Khariswara has a high diversity of crops, including a large number of vegetables, productive rice terraces and a variety of fruit trees. This diversity is due to high soil productivity, maintained through terracing, animal and chemical fertilizers, an ancient irrigation system and good knowledge about crops and techniques. Of all study sites, Khariswara is one of the better off in terms of income, education, land ownership, soil productivity, organizational capabilities and access to information and government officials locally and in Kathmandu (Table 18). The reasons are historic and linked to the advantaged place given to high caste *Brahmins/Chhetris* in Nepal society and Khariswara: they are traditionally the scholars, priests and teachers (Bista, 2004; Gaborieau, 1995). The reason Khariswara was selected was for the very acute

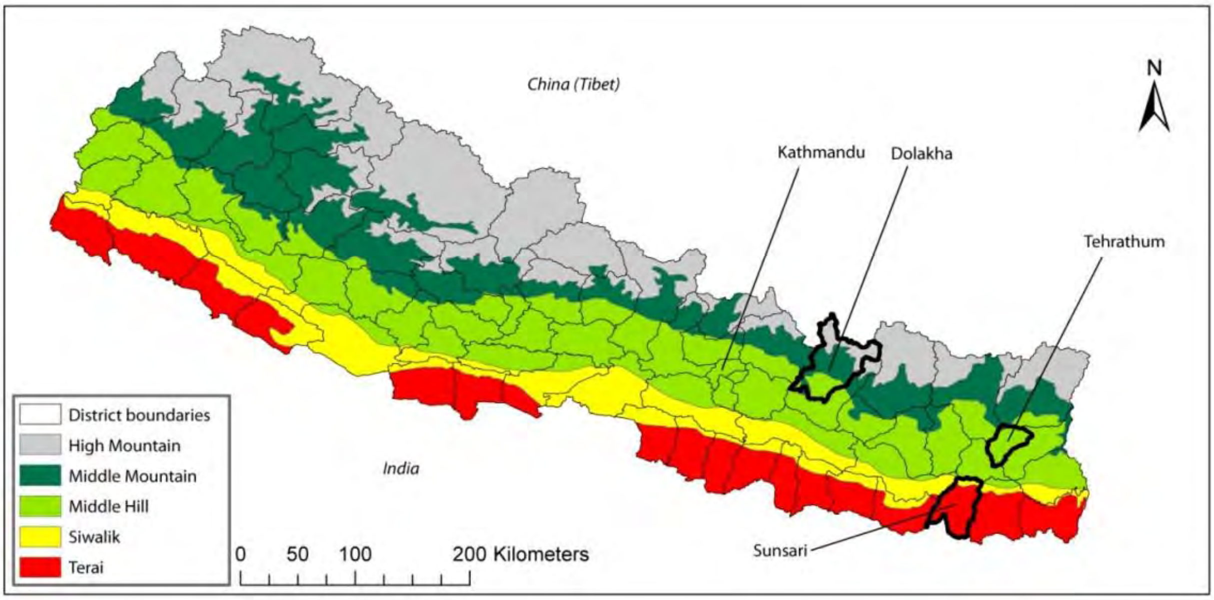


Figure 60. District map Central and Eastern Nepal with survey sites. Jaquet, 2011b

nature of the landslide, which occurred during our geologists' field visit on September 15, 2010 and for the high social status of the village. The region was selected initially based on recommendation by our host organization, (NSCFP).

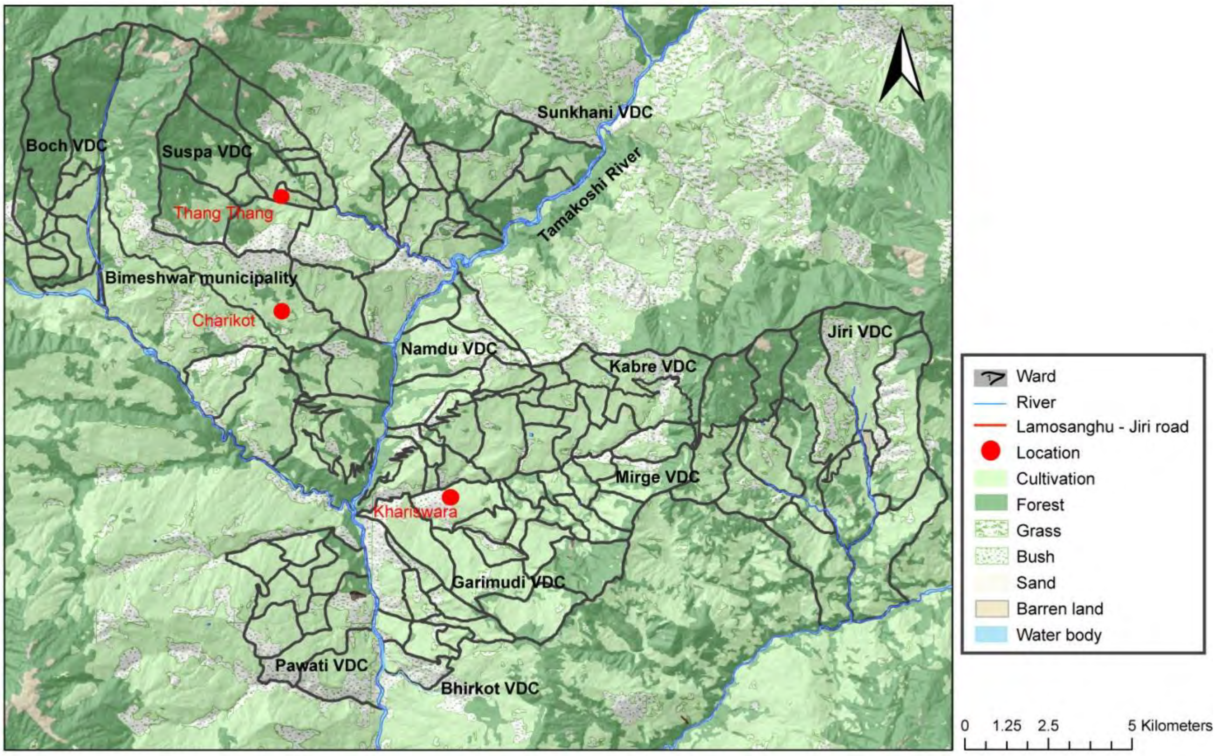


Figure 61. Situation map, Dolaka district (Jaquet, 2011b)

Khariswara environmental context

- Average rainfall: 1568 mm with a maximum 24 hours rainfall of 201mm;
- The area is characterized by productive soils and high crop diversity, mainly rice, millet and vegetables, some fruits;
- Highly productive rice fields *khet* thanks to centuries old irrigation system emanating from perennial spring, located in the landslide area and most likely the landslide trigger;
- The spring was the village's main drinking source and a water tank now supplies water but the supply and quality are poor;
- One of the village's main assets is high quality talc, used for painting houses white and very abundant here. It is another cause of the landslide as talc, combined with water has very low soil cohesion;
- A quarry was developed 500 m west of the settlement and abandoned several years later after it caused the destruction of a self-financed access road;
- The CF Gauthalibhir,(9 ha) was established over 15 years ago and lies entirely within the village. As a result, most of the livestock are kept in pens and fodder is collected;
- It is managed by a CFUG, which seems well-managed according to the community.

Textbox 3

Figure 62. Top left: Khariswara house and barn; top right: rice fields converted to millet; bottom right: bamboo Grove; bottom left: animal pen. 2010

Khariswara geological context

- Kusma formation, which is basically phyllites and quartzite, talc and laterites;
- Top regolith is lateric soil, red in color and fairly deep;
- Subsurface of the area is full of highly weather quartzite inter-bedded with talc minerals with very poor soil cohesion but good soil productivity;
- Previous landslides 20 years ago affected lower parts of the village and any land changes were closely monitored;
- September 15, 2010 a rotational type landslide ca. 350,000 m3 was triggered by several weeks of heavy rainfall, likely aggravated by the spring;
- 3 ha of *khet* and valuable community forest were lost, as well as the irrigation system, main water spring and main trail for children to go to school;
- In recent years, the spring had moved downward, making it necessary to rebuild the

Textbox 4

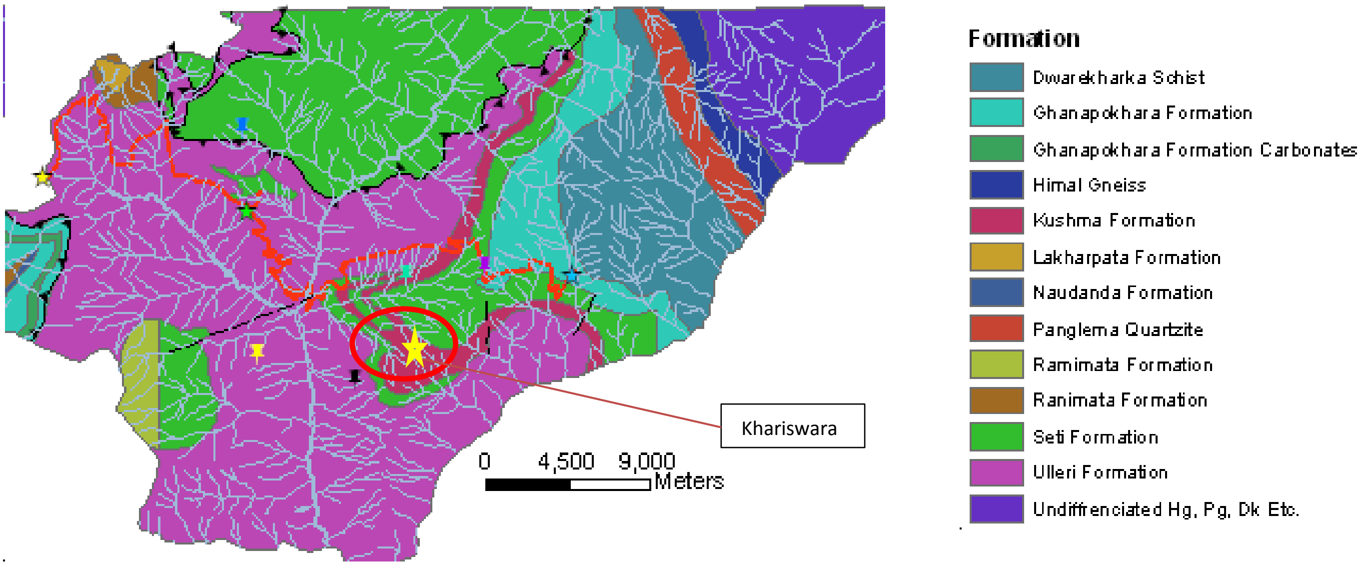


Figure 63. Geological map of Dolakha district (Devkota et al. 2011)

Figure 64. Top left: Khariswara village in April 2010 (Jaquet/ 2010); top right: Khariswara village in October 2010 (Jaquet/2010); middle right: Khariswara village in March 2011 (Devkota/2011); bottom right, cracks in April 2010; bottom left: self-funded collapsed access road, October 2010; middle left: landslide, October 2010. (Jaquet/2011)

Khariswara social context

- The high caste community *(Chhetri),* has been settled here for generations, with no recollections of previous origins;
- A relatively well-off village in terms of food security, landholdings, remittances and education;
- Houses are usually 2-storeys, with separate barns and outdoors pen for livestock;
- Several families with sons abroad sending regular remittances;
- New school built close to village, school teacher lives in village;
- Earthen VDC road exists 100 meters from village but is only practicable during dry season;
- Village built their own access road which collapsed with first monsoon rain
- Having an access road in spite of the inappropriate location is a priority as roads bring social status and opportunities;
- A very organized and active village, as they had contacted the media and various government agencies to seek assistance after the landslide;
- Has received assistance from a local NGO, Tuki, to install drinking water taps, sanitation, agricultural outreach and women's savings groups;
- Active in collective projects, such as building a self-funded access road even before the landslide
- A very cohesive social structure: all decision making and problem solving is based on consensus and regular meetings;
- A well-organized Community Forest User Group (CFUG).

Causes of landslide

- A majority believed that the landslide was caused by "weak geology", underground water and heavy rainfall.
- Some respondents, mainly female, explained the landslides as being caused by a holy stone that angered the Gods – snakes in the slope - when it was placed in a temple on the other side of the river;
- None of the respondents felt that human interventions, such as the irrigation canal, may have contributed to the landslide problem.

Coping strategies

- The community has organized itself into committees and is extremely active in trying to find some solution to mitigating the landslide, as well as considering relocating their village to another site;
- After September 2010 landslide, the population contacted all relevant government officials and the media to report the incident, hoping to receive technical assistance to mitigate the landslide and compensation for the cracked house;
- A Soil Conservation officer visited the village only to confirm there was nothing he could do about the landslide (pers. comm, 2010);
- During heavy rainfall, residents closest to the landslide spend the night with neighbors farther away;
- Investment in more diverse rain-fed crops, especially ground nuts, on terraces away from the landslide area;
- Outmigration: one of the younger men whose family had lost most of their land to the landslide is migrating to Qatar.

Risk perceptions

- Fourteen houses, or half of the village, are at high to medium risk, similar to the study team's estimation of risk (Section 5.1.3).
- This high estimate of risk was similar for men and women;
- The population was aware of cracks and bulging of fields during the first field trip in April 2010 but continued to cultivate fields, while monitoring movement.

Priorities

- The men's main priorities were to mitigate the landslide, followed by repair of the collapsed road and irrigation system, education, village development, and health;
- The women were more concerned with the need to maintain social harmony, without which it was not deemed possible to conduct landslide mitigation, rebuild the irrigation canal or their collapsed access road.

Textbox 5

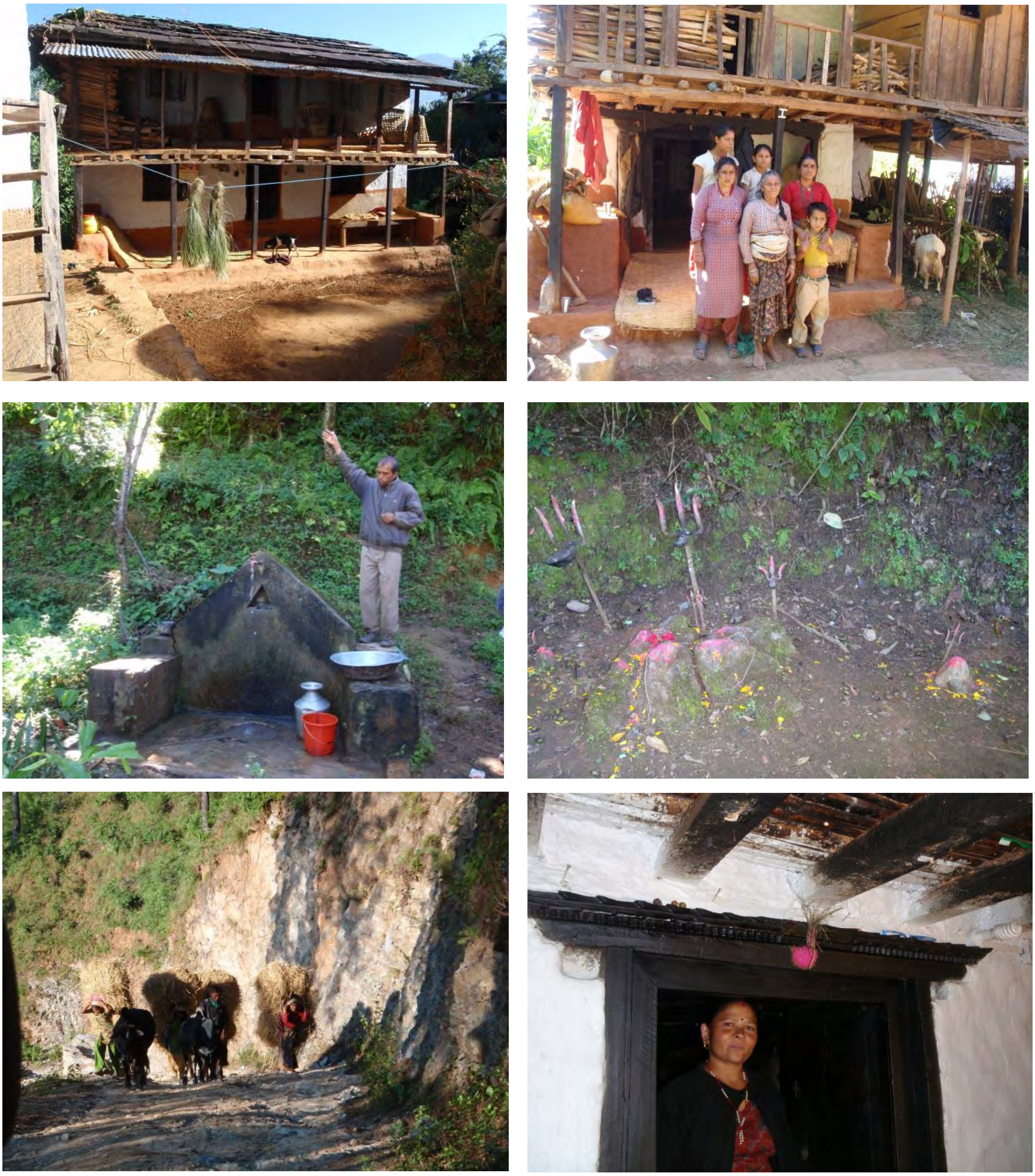


Figure 65. Top left: Khariswara house; top right: Chhetri family; middle right: Temple; bottom right: entrance to Chhetri house; bottom left: transporting fodder; middle left: pump installed by Tuki NGO.

5.1.2. Social context: Participatory exercises

In order to map community priorities, risk perceptions, (Abbot et al., 1998; Anderson & Woodrow, 1998) resources needed for everyday life, threats to the village and linkages between resources a participatory "social mapping" exercise was undertaken with men and women separately. By mapping resources needed for "everyday life", we can better understand community priorities, how the community considers landslide mitigation in terms of responsibilities and linkages between resources. Figure 67 and Figure 67 illustrate the exercises conducted by the women focus groups in the two communities. Focus group participants were first asked to list resources, group them, name the groups and last, to link the various resources. Sometimes linkages were made between individual resources, other times between groups of resources. At times, focus group participants confused resources with needs, such as group 3, " community priorities" (Figure 69). However by allowing the community the liberty to define their social resources map, they were allowed to articulate their priorities. The women were more concerned with the need to maintain social harmony, without which it was not deemed possible to conduct landslide mitigation, rebuild the irrigation canal or their collapsed access road.

Figure 66. Left: Men's focus group discussion; right: women focus group discussion, October 2010.

Figure 67. Khariswara women's social map, October, 2010

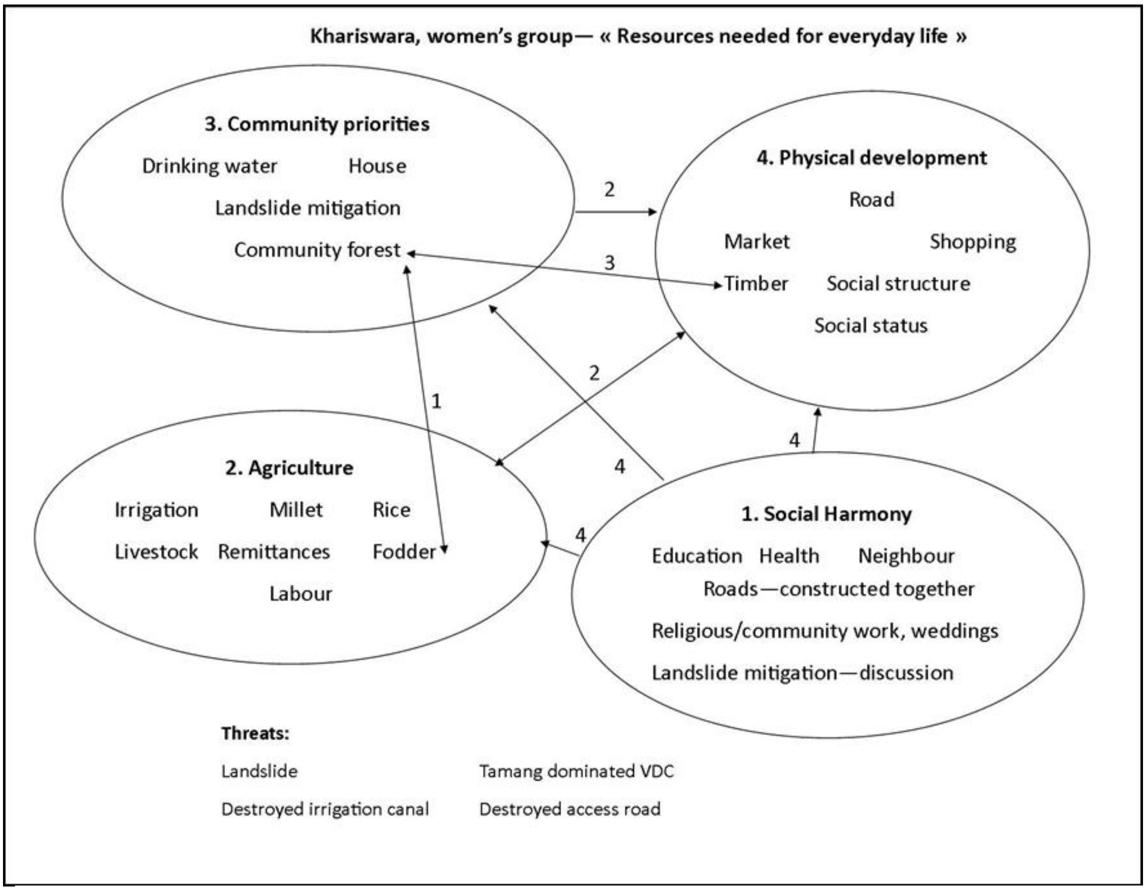


Figure 68. Khariswara women's social map, October, 2010 (translation)

Figure 69. illustrates the 'Men's social map', which differs from the women's map in style and content, perhaps due the difference in translating instructions and facilitation. The men's social map is organized according to five different types of resources: natural, social relations, human resources, physical infrastructure, economic activities. The men

mapped out a strategy for improving each of these areas. Arrows were drawn to show linkages and priorities between these different resource types and types of activities required for improving each. These linkages and priorities are described in the rectangle "linkages – priorities" and are enumerated according to the importance accorded by participants. The most common theme and priority mentioned was education, followed by improvements in forest management soil conservation and landslide mitigation.

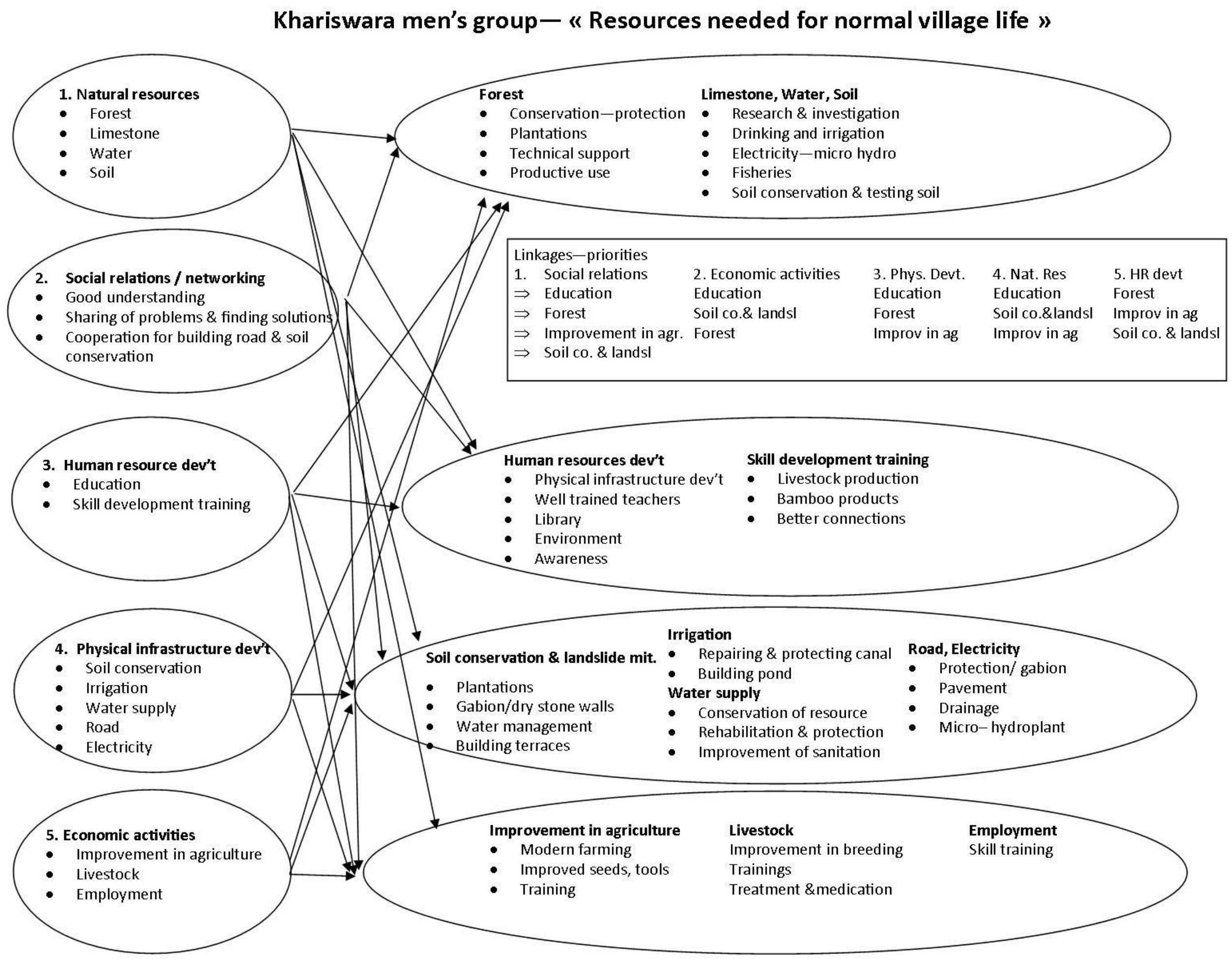


Figure 69. Khariswara men's social resource mapping, October 2010 (translated)

We provided a mixed group with an earlier set of 25 indicators of resilience, which were developed over the course of this research, based on an extensive literature review, field observations and stakeholder discussions. We presented the indicators as resources needed during an emergency, (not as resilience indicators as this term was not understood). Due to busy schedules, two of the village elders worked with the indicators for two hours, re-ordering them into groups (Figure 70). Of the 25 indicators, only one was not retained: access to markets. The reason was that " *we don't have time to go to the market during an emergency*". The remaining indicators were placed in five groups: in case of emergency, awareness, preparedness, work done by group, in case of external help.

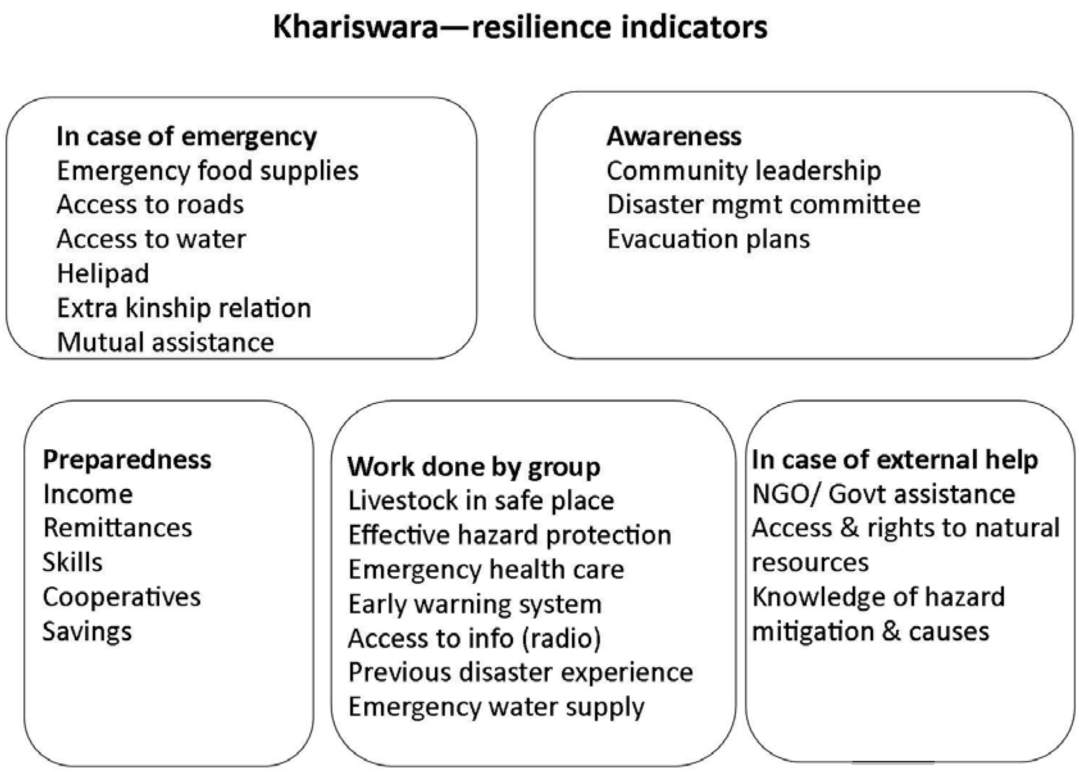


Figure 70. Khariswara men resilience map, October, 2010 (translated)

5.1.3. Risk assessments

5.1.3.1. Participatory risk map

During the first field trip in April 2010, before the most recent landslide in September, the population was aware of cracks and bulging of fields. They told of a looming large landslide but still continued to cultivate their rice fields during the monsoon season (Figure 71). According to one respondent: "*If we die, we die. But if we live, we need to eat."* Community members were given a large sheet of paper A1, colored pencils and asked to draw the main features of their community, with houses colored in red for most at risk, orange less at risk, and yellow least at risk. According to the Khariswara community risk map (Figure 72, Figure 73), fourteen houses, or half of the village, are at high to medium risk, similar to the study team's estimation of risk (Figure 74, Figure 75). The high estimate of risk was similar for men and women. Other important features marked on the map are two sacred trees, two temples, the school, trails, community forest, *khet* and *bari* fields, the *pahiros* (landslide areas) and sources of water.

A majority of respondents lost some portion of their land, valuable community forest and most importantly, the irrigation system ensuring the cultivation of rice. A majority of the community believed that the landslide was caused by "weak geology", underground water and heavy rainfall. Some respondents, mainly female, explained the landslides as being caused by a holy stone that angered the Gods – snakes in the slope - when it was placed in a temple on the other side of the river. However, none of the respondents felt that human interventions, such as the irrigation canal, may have contributed to the landslide problem. This duality of beliefs, both supernatural and observational is consistent with other studies of Nepal risk perceptions and causes of landslides (Bjornness, 1986; Gurung, 1989; Smadja, 1997).


Figure 71. Left: destroyed fields; right: Khariswara man and boy in front of landslide, October 2010.

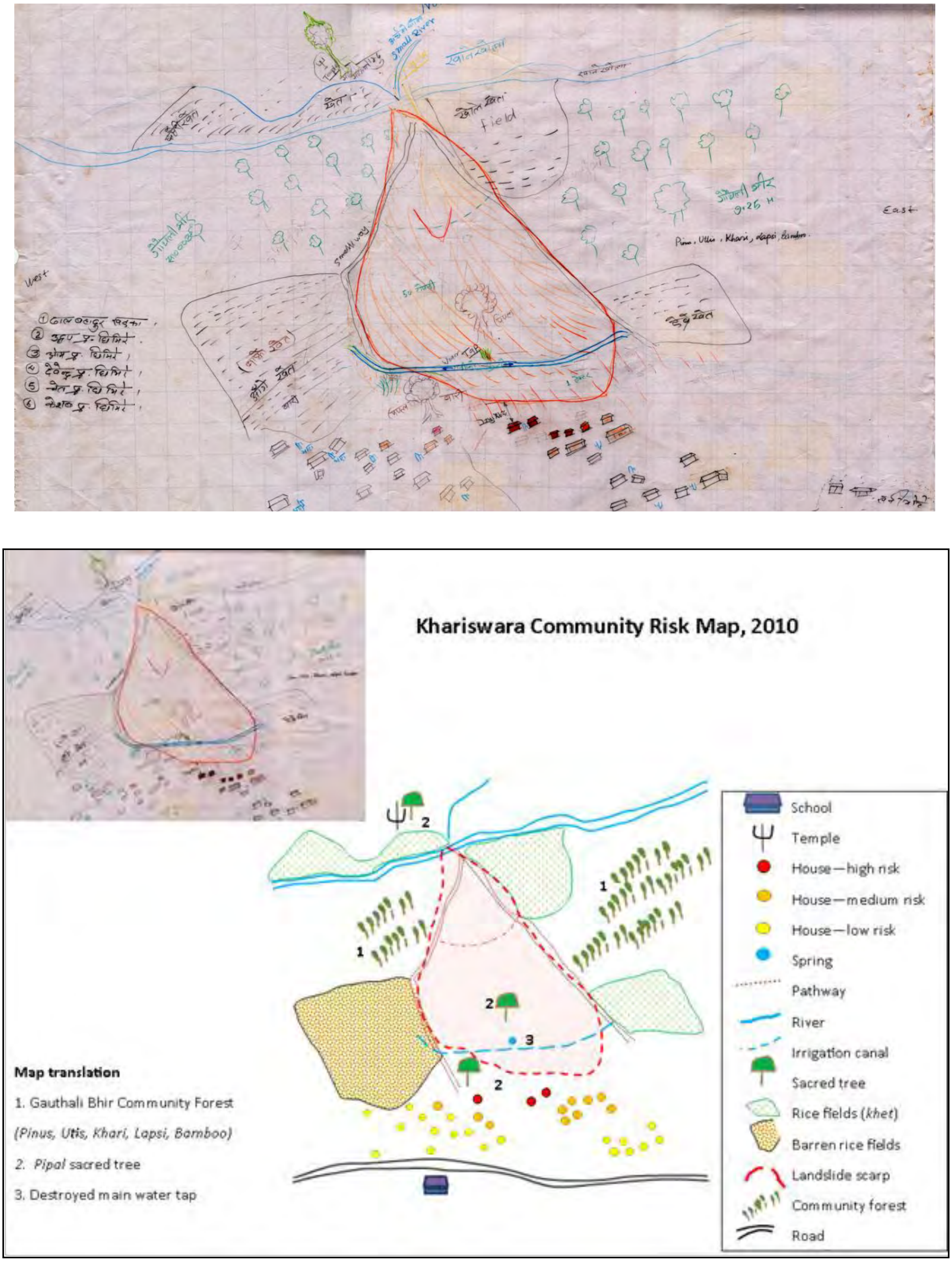


Figure 72. Khariswara participatory risk map, October, 2010

Figure 73. illustrates the same community risk map but transferred into a GIS map to facilitate comparison with the following risk maps. Interestingly, the community risk map actually describes a higher level of risk then the "geologist's risk map", or the "composite risk map", although this comparison needs to be considered as very rough as we do not know exactly what timescale that the community had in mind, as compared to our timescale of 50 years for the other risk maps.

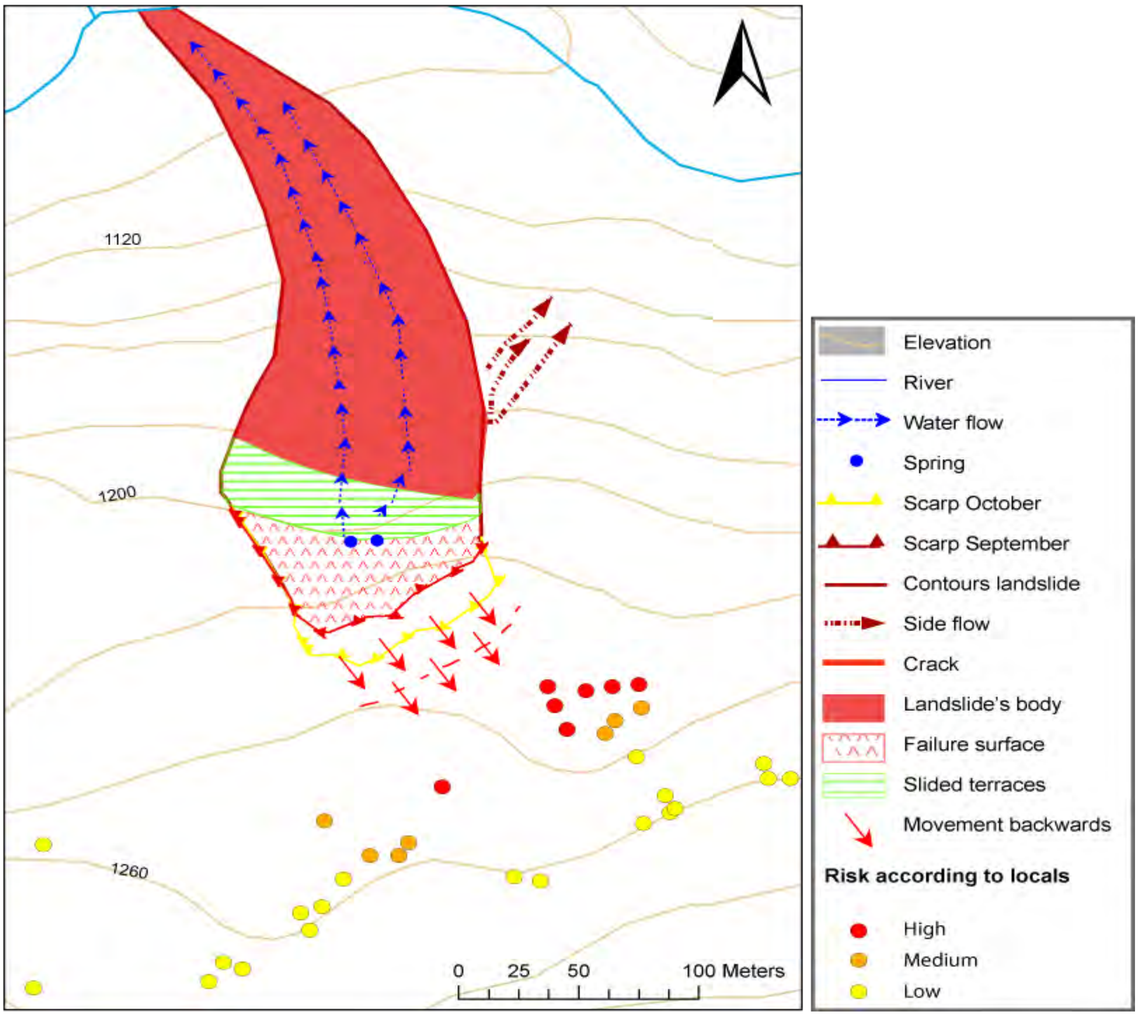


Figure 73. Risk map according to community, Khariswara. (Jaquet, 2011b)

5.1.3.2. Geologist's risk map

The geologist's risk map (Figure 75) defines risk using the natural science definition of risk.

$$R = H \times V \times E \times W$$

Risk was calculated for each building based on an assessment of the landslide movement, its speed, direction, activity, evolution of the area and topography (Jaquet, 2011b) (Table 20). For Khariswara, two scenarios were developed: progressive landslide movement and sudden landslide movement. For the risk assessment; the progressive scenario is presented here. This scenario predicts a progression of the landslide by 6 meters per year in the south east direction, determined with features visible in the field. Based on this calculation, the return period was estimated at 30 years (0.03). With this hypothesis, the houses located on the south west are not in the affected area. Thus probability that an event occurs in the next 50 years is high (> 50 %) for the houses located in the direction of the retrogressing scarp (Modified from Jaquet, 2011b)(Table 20). (The 50 year period was used for high risk in order to be consistent with previous risk maps developed for the case studies on Sabra and Katahare.) The other houses are less likely to be affected by an event in the next 50 years. Under this scenario, the exposure is quite low for people in the south west direction. The landslide is being monitored very closely: 3 times a day during the rainy period, reducing exposure as any movement will entice the population to evacuate. According to the geologists' definition of vulnerability (0.5) this figure is not maximal (1) but still high. If the landslide is behaving like predicted, houses at risk will collapse and could cause fatalities, 5.5 per house (average per house) (Jaquet, 2011b). Table 20. Illustrates the data used for calculating the "geologist 's risk map", based on the methodology described above and in the methods chapter.

For example, based on the risk equation : R=H ×E ×V ×W, for the House (GPS 958) , risk is:

$$0.003 \times 0.1 \times 0.5 \times 5.5 = 0.00825$$

Projected risk is high: 1 house is at high risk, 17 are at medium risk and 15 are at low risk (Table 20) .

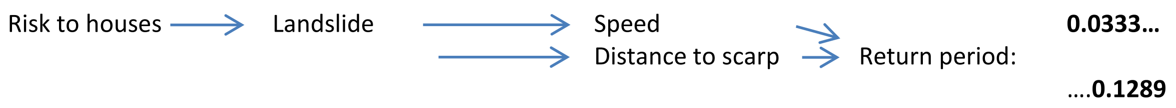


Figure 74: Methodology for determining the hazard in Khariswara (Modified from Jaquet, 2011b).

Id	Distance [m]	Vulnerability (2) (V)	Exposure (2) (E)	Loss (W)	Hazard (H)	Risk (2)
958	115	0.5	0.1	5.5	0.0300	0.00825
974	85	0.5	0.1	5.5	0.0300	0.00825
979	149	0.5	0.1	5.5	0.0300	0.00825
970	351	0.5	0.1	5.5	0.0300	0.00825
981	119	0.5	0.1	5.5	0.0300	0.00825
973	116	0.5	0.1	5.5	0.0300	0.00825
49	126	0.5	0.1	5.5	0.0300	0.00825
50	150	0.5	0.1	5.5	0.0300	0.00825
53	123	0.5	0.1	5.5	0.0300	0.00825
54	90	0.5	0.1	5.5	0.0300	0.00825
55	75	0.5	0.1	5.5	0.0300	0.00825
56	160	0.5	0.1	5.5	0.0300	0.00825
956	89	0.5	0.1	5.5	0.0300	0.00825
957	100	0.5	0.1	5.5	0.0300	0.00825
959	145	0.5	0.1	5.5	0.0300	0.00825
960	196	0.5	0.1	5.5	0.0300	0.00825
48	149	0.5	0.1	5.5	0.0402	0.01106
950	142	0.5	0.1	5.5	0.0423	0.01163
47	136	0.5	0.1	5.5	0.0441	0.01212
949	124	0.5	0.1	5.5	0.0482	0.01326
968	124	0.5	0.1	5.5	0.0484	0.01330
46	122	0.5	0.1	5.5	0.0493	0.01356
45	117	0.5	0.1	5.5	0.0513	0.01412
52	95	0.5	0.1	5.5	0.0630	0.01732
978	80	0.5	0.1	5.5	0.0751	0.02066
953	79	0.5	0.1	5.5	0.0763	0.02099
44	76	0.5	0.1	5.5	0.0785	0.02160
41	72	0.5	0.1	5.5	0.0830	0.02282
43	67	0.5	0.1	5.5	0.0892	0.02452
955	65	0.5	0.1	5.5	0.0928	0.02551
976	64	0.5	0.1	5.5	0.0934	0.02568
51	58	0.5	0.1	5.5	0.1035	0.02847
42	56	0.5	0.1	5.5	0.1081	0.02972
954	47	0.5	0.1	5.5	0.1289	0.03544

Table 20. Data for estimating "geologists" risk in Khariswara (Jaquet, 2011b)

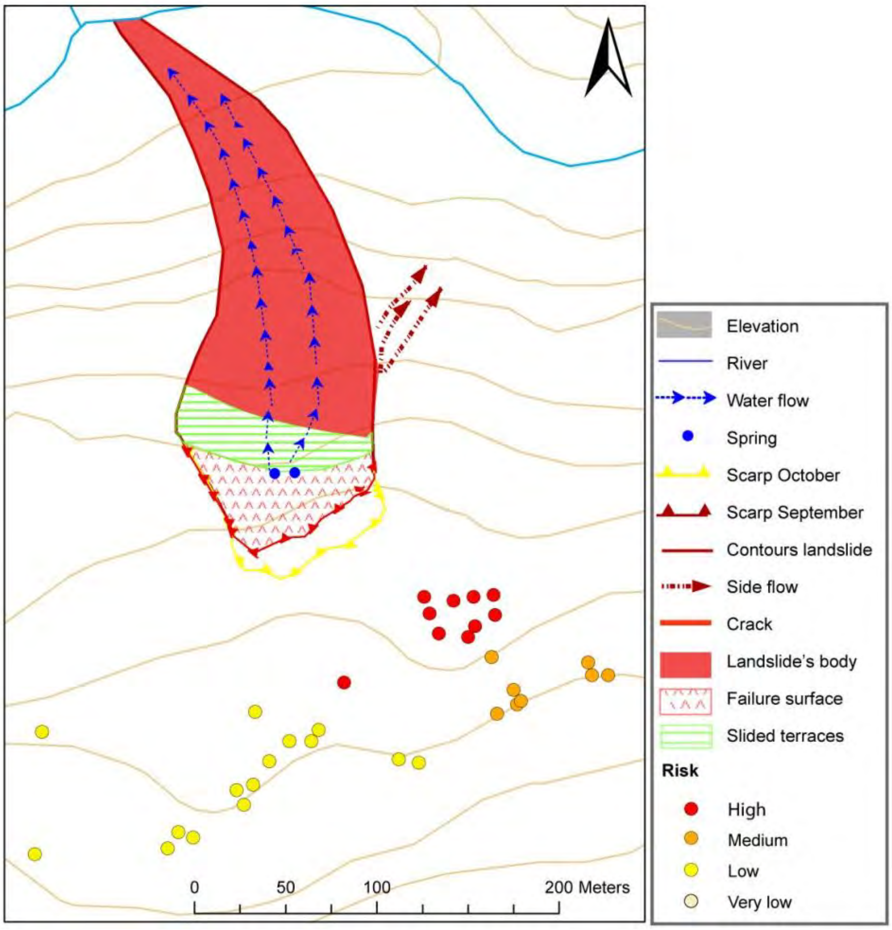


Figure 75. Geologist's risk map, Khariswara (Jaquet, 2011b)

Class	Timeframe	No. of houses (casualties)
High	Within 50 years	10 (55)
Medium	50-100 years	8 (44)
Low	100-200 years	15 (82.5)
Very low	200 + years	-

Table 21. Khariswara risk predictions, geologists' risk map.

5.1.3.3. Composite risk map

The following map, called "composite risk map" was developed to better reflect the UNISDR definition of vulnerability, to encompass various dimensions of vulnerability (Figure 76). To do so, each household was assigned a vulnerability score based on the household survey and divided by the maximum score possible to obtain a normalized vulnerability score (Table 22). As each house was geo-referenced, it was possible to develop a composite risk map. As approximately half of all households were surveyed, the remainder were given a mean value in order to have a comparable risk map.

Id	Distance [m]	Vulnerability (COMP) (V)	Exposure (2) (E)	Loss (W)	Hazard (H)	Risk (COMP)
958	115	0.45	0.1	5.5	0.0300	0.00737
974	85	0.41	0.1	5.5	0.0300	0.00682
979	149	0.49	0.1	5.5	0.0300	0.00803
970	351	0.49	0.1	5.5	0.0300	0.00814
981	119	0.52	0.1	5.5	0.0300	0.00858
973	116	0.45	0.1	5.5	0.0300	0.00748
49	126	0.48	0.1	5.5	0.0300	0.00792
50	150	0.48	0.1	5.5	0.0300	0.00792
53	123	0.48	0.1	5.5	0.0300	0.00792
54	90	0.48	0.1	5.5	0.0300	0.00792
55	75	0.48	0.1	5.5	0.0300	0.00792
56	160	0.48	0.1	5.5	0.0300	0.00792
956	89	0.48	0.1	5.5	0.0300	0.00792
957	100	0.48	0.1	5.5	0.0300	0.00792
959	145	0.48	0.1	5.5	0.0300	0.00792
960	196	0.48	0.1	5.5	0.0300	0.00792
48	149	0.48	0.1	5.5	0.0402	0.01062
950	142	0.41	0.1	5.5	0.0423	0.00961
47	136	0.48	0.1	5.5	0.0441	0.01164
949	124	0.52	0.1	5.5	0.0482	0.01379
968	124	0.47	0.1	5.5	0.0484	0.01241
46	122	0.48	0.1	5.5	0.0493	0.01302
45	117	0.48	0.1	5.5	0.0513	0.01356
52	95	0.48	0.1	5.5	0.0630	0.01663
978	80	0.47	0.1	5.5	0.0751	0.01928
953	79	0.51	0.1	5.5	0.0763	0.02127
44	76	0.48	0.1	5.5	0.0785	0.02074
41	72	0.48	0.1	5.5	0.0830	0.02190
43	67	0.48	0.1	5.5	0.0892	0.02354
955	65	0.48	0.1	5.5	0.0928	0.02449
976	64	0.60	0.1	5.5	0.0934	0.03082
51	58	0.48	0.1	5.5	0.1035	0.02733
42	56	0.48	0.1	5.5	0.1081	0.02853
954	47	0.48	0.1	5.5	0.1289	0.03402

Table 22. Data for composite risk map. (Modified from Jaquet, 2011b)

We note that the composite risk map indicates practically the same number of houses in the high risk category, considering the same time period of 50 years. The large time scale chosen produces very little difference between geologist's and the composite risk map. The choice of 50 years for the high risk category can be questioned and is probably too long considering the average life span of most Nepalis. This is because the composite estimation of risk also takes into account social economic factors. Interestingly, they both closely reflect the community risk map.

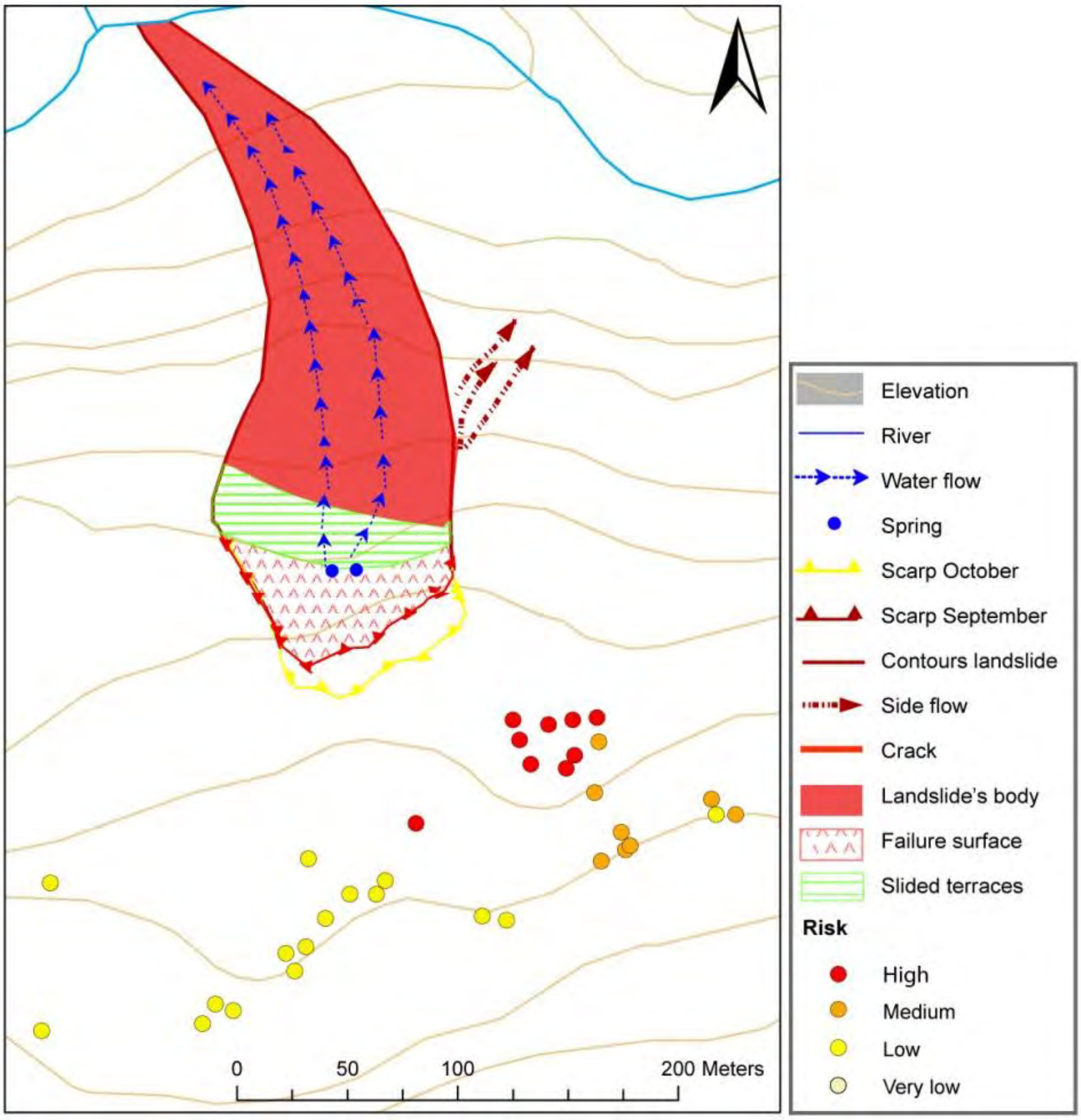


Figure 76. Composite risk map, Khariswara. (Map by Jaquet et al., 2011c)

Class	Timeframe	No. of houses (Casualties)
High	Within 50 years	9 (49.5)
Medium	50-100 years	8 (44)
Low	100-200 years	16 (88)
Very low	200 + years	

Table 23. Khariswara risk predictions, composite risk map.

5.1.4. Synthesis and discussion

Khariswara's situation is one of the most acute of the case studies. Previous landslides 20 years ago affected parts of the village and any land changes were closely monitored. The September 15, 2010 landslide has severely disrupted this village's functioning. Fortunately there were no victims and no major damage to houses, except for the destruction of 3 ha of rice fields and forest, the loss of livestock and the centuries old irrigation system. During the following month, the landslide grew upslope by at least 5 meters, at approximately 30 cm per day, causing one house to crack and placing one third of the village at high risk. By October, 2010, the scarp of the landslide was 45 meters below the closest house and inching its way toward the main hamlet 100 meters above. This is a large and deep-seated landslide; simple mitigation measures are not likely to reduce the advancing landslide. However several measures may help: managing the spring/ground water and filling in the cracks at the head scarp can help to retain the surface water from entering into the landslide body. Horizontal drainage boring may help but is a costly intervention (Devkota et al. 2011). Evacuation of houses closest to the scarp is recommended but not likely to be undertaken by the authorities.

Even before the 2010 landslide, Khariswara had been extremely active in collective projects, such as building a self-funded access road (which collapsed during the following monsoon season). The village has a very cohesive social structure where all decision making and problem solving is based on consensus and regular meetings, clearly demonstrated through active involvement in the well-organized Community Forest User Group (CFUG). Immediately after the September 2010 landslide, the population contacted all relevant government officials and the media to report the incident, hoping to receive technical assistance to mitigate the landslide and compensation for the cracked house. A Soil Conservation officer visited the village only to confirm there was nothing he could do about the landslide (pers. comm, 2010).

The community has organized itself into committees and is extremely active in trying to find some solution to mitigating the landslide, as well as considering relocating their village to another site. This would be an expensive strategy but one that the village is able to undertake considering their relatively good economic situation. During heavy rainfall, residents closest to the landslide spend the night with neighbors farther away. One strategy is to invest in more diverse rain-fed crops, especially ground nuts, on terraces away from the landslide area. Another is outmigration: one of the younger men whose family had lost most of their land to the landslide is migrating to Qatar. Before the landslide, most households had received technical assistance from a local NGO, diversified their income base, combined with emigration and investing in education, which is something their higher caste status has allowed this community to do. These active strategies are consistent with Burton et al's (1993) typology of "acceptance", quite typical of hierarchists, with strong cohesion and expectations of authorities (Douglas and Wildavsky, 1982) but also good access to resources (Sen, 1982; Wisner et al., 2004)

5.2. Case study II Thang thang/ Gairithok village

Thang thang/Gairithok Villages Fact sheet	
Village location	**Wards 4 and 9** **Suspa VDC** 27°41'56.59''N, 86°2'19.01''E 1400-1500 m.a.s.l.
Average annual rainfall	2000 mm
Surveyed population	n= 13, ca. 35 persons in focus group discussions
Population size	23 households (ca. 120 persons)
Average household size	5.3 persons
Occupations	Field laborers, road construction, quarrying.
Average loss due to landslide	1.2 ha rice fields lost; 3.8 ha community forest lost 5 ha converted to drylands ca. 50% of houses cracked
Geology	Highly weathered schist inter-bedded with phylites Poor soil cohesion Village located on Main Central Thrust (MCT) Low soil productivity
Land use	Mainly millet, some rice, few vegetables and fruits.
Average age	27 years
% families with one member abroad	23 %
% families receiving remittances	8%
Ethnic group	*Thami* (indigenous disadvantaged)
Average land holding	0.16 ha
Literate	7%
Average food supply	4.1 months
Average % mobiles	23%
Electricity	84%
Good sanitation facilities*	31%
Community priorities	Skills training for developing income generating activities with forest products, such as paper and herbs; literacy for their children; landslide mitigation.

Table 24. Thang thang/Gairithok Villages Fact sheet

Thang thang/Gairithok villages	
Village location	**Wards 4 and 9, Suspa VDC, Dolakha district,** 27°41'56.59''N, 86°2'19.01''E 1400-1500 m.a.s.l.
Surveyed population and methods	n= 13 surveys and in-depth interviews (48% of pop) ca. 35 persons in 2 focus group discussions transect walk risk mapping exercise social mapping Google map satellite image, 2007 Topographic map 1:10,000

Table 25. Thang thang/Gairithok, research methods

5.2.1. Overview

Thang thang/ Gairithok village is also situated in the Middle Hills of Dolakha district (27°41'56.59''N, 86°2'19.01''E), with a somewhat higher annual rainfall at 2000 mm and elevation 1400-1500 m.a.s.l. (Figure 77). Geographically, they are both located on similar north to north-west facing slopes and climates; the two communities are located at only 20 km distance but differ significantly. Thang thang/ Gairithok is a so-called low-caste, indigenous *(Thami)* community, where the main crops are mainly millet, some rice, few vegetables, no fruit trees and low food security is prevalent. The *Thamis* on the other hand, traditionally work in stone quarries with little emphasis placed on education and are often

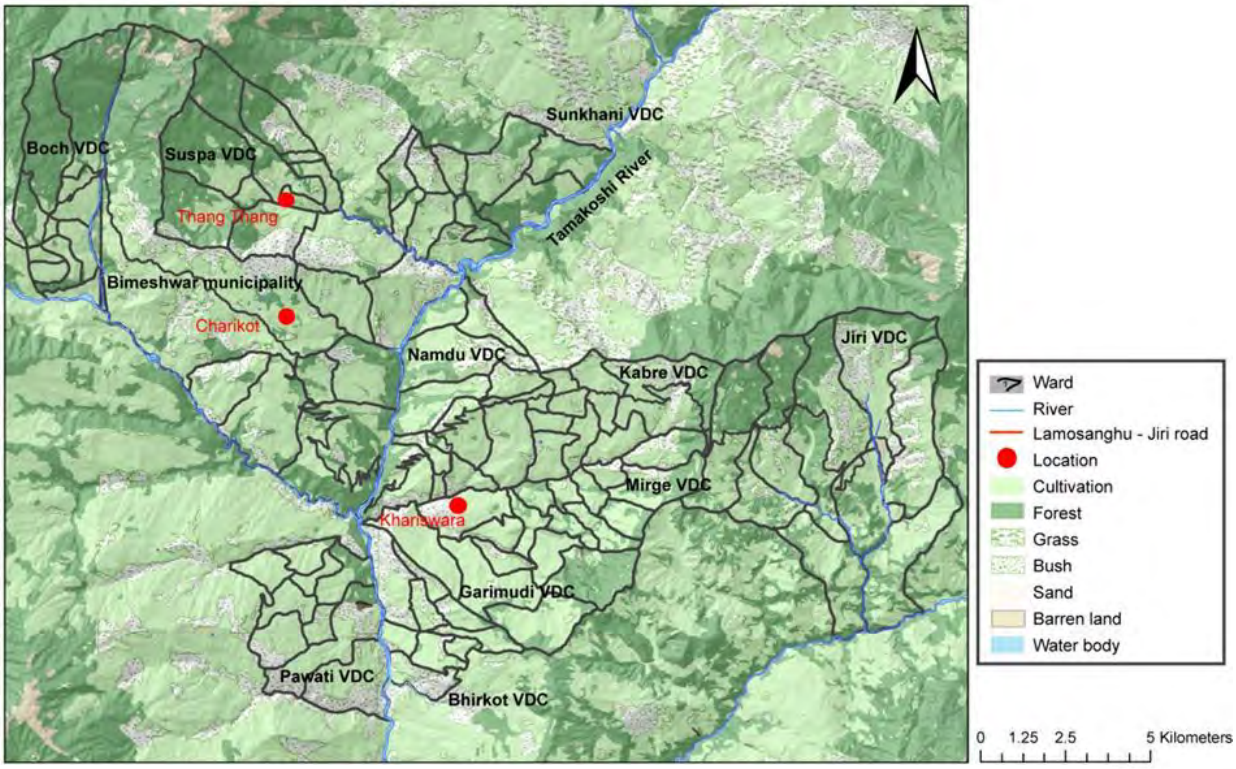


Figure 77. Situation map, Dolakha, 2009. Jaquet, 2011b

marginalized by more powerful groups (NDFIN, 2001). This ethnic group is considered one of the original nomadic tribes of Nepal, most likely originating from Mongolia (Gaboriaux, 1995). According to the latest 2001 census, there are only 30,000 Thamis remaining in Nepal (CBS, 2009a). They traditionally practice their own religion but many have also incorporated Hindu and Bouddist practices (Figure 78).

Thus socially and economically, Khariswara and Thang thang communities are very different, however they are affected by similar levels of high landslide risk. Although landslides in Thang thang /Gairithok are currently less acute, future landslide activity is highly probable. The village lies above an active landslide and seepage from earthen irrigation canals poses a significant risk for debris flows. One of Nepal's main earthquake thrusts, the Main Central Thrust (MCT) runs near Thang thang /Gairithok (Stocklin, 1980) and is the likely trigger of a deep-seated translational landslide ca. 280,000 m3 which occurred in 1986. As a result, circa 3 ha of land was lost, with nearly all families losing terraces and much land was converted to growing maize, instead of more valuable rice (Table 24). The bottom part of the landslide is considered a fast moving landslide as a new gabion wall to protect the road moved 1,5 meters since April 2010 and is about to collapse, while the upper part is slow moving. Most houses in the village have several cracks and have been moved by owners to another part of the village perceived as safer, although a majority of houses are considered at high risk in accordance with the geologists' risk assessment. Several houses have seasonal springs, indicating high levels of ground water, probably aggravated by the irrigation canals (Figure 79).

Figure 78. Mixed Hindu and local religion symbols, Thami house, October 2010.

Thang thang /Gairithok environmental context (Figure 79)

- Average rainfall: 2000 mm;
- The indigenous, low caste community (*Thami*), has been settled here for generations, with no recollections of previous origins;
- The areas soils are less productive soils and crop diversity is lower, mainly millet, wheat and vegetables, no fruits;
- The village is bordered by a chronic landslide below, and threatened by debris flows above.
- During the monsoon, it is surrounded by large quantities of water: a fast moving perenninal torrent and two smaller torrent that become “raging” during heavy rainfall;
- Two irrigation canals are very contentious as they were built for a neighboring high-caste community (Siwakoti), the canals are considered dangerous as they are seeping water into slopes and could trigger debris flows;
- Suspa VDC is largely forested, its forest cover increased from 49% in 1979 to 60% in 2009 . Forests are most often located on steeper sloes and near rivers, areas often not suitable for agriculture(Jaquet, 2011b);
- The community has access to three CFs: Raisnite CF, Gumphu Mahasun CF and Damar CF, which have a total extent of 841.96 ha spread across several wards on the upper part of the basin, where the village is located. They were established over 16 years ago;
- The CFs providing useful products: firewood, timber, fodder and medicinal plants and poaching has decreased as a result, according to respondents;
- The CF is managed by a CFUG, which has management problems, according to the community, mainly due to dominance by a neighboring upper caste community;
- In spite of irregularities with management of the CF, the community has reported improved forest quality as most of the livestock are kept in pens and fodder is collected.

Textbox 6

Figure 79. Left: cemented irrigation canal. Right: partly cemented irrigation canal, October 2010.

Figure 80. Top left: landslides scarp, April 2010 (Derron/2010). Top right: millet fields below scarp, Oct. 2010; bottom right: Thami house; bottom left: millet fields below landslide area. October 2010.

Thang thang /Gairithok geological context

- Seti formation, highly weathered schist inter-bedded with phylites and quartzite (Figure 81)
- Poor soil cohesion and low soil productivity.
- Exposed bedrock is highly fractured and contains numerous horizontal joints.
- This can be explained by the village being located on Main Central Thrust (MCT)
- Thus earthquake movement is a likely trigger of a deep-seated translational landslide ca. 280,000 m3 which occurred in 1986.
- Preliminary estimates indicate that the depth of the soil, which is slowly moving is about 8-12 meters.
- High monsoonal rain, slope and soft soil cover and ground water have made this area highly susceptible to failure.
- 3 ha of land was lost, with nearly all families losing terraces.
- The bottom part of the landslide is considered a fast moving landslide as a new gabion wall to protect the road moved 1,5 meters since April 2010 and is about to collapse, while the upper part is slow moving (Figure 82).
- Several houses have seasonal springs, indicating high levels of ground water, probably aggravated by the irrigation canals, adding the possibility of debris flow.

Textbox 7

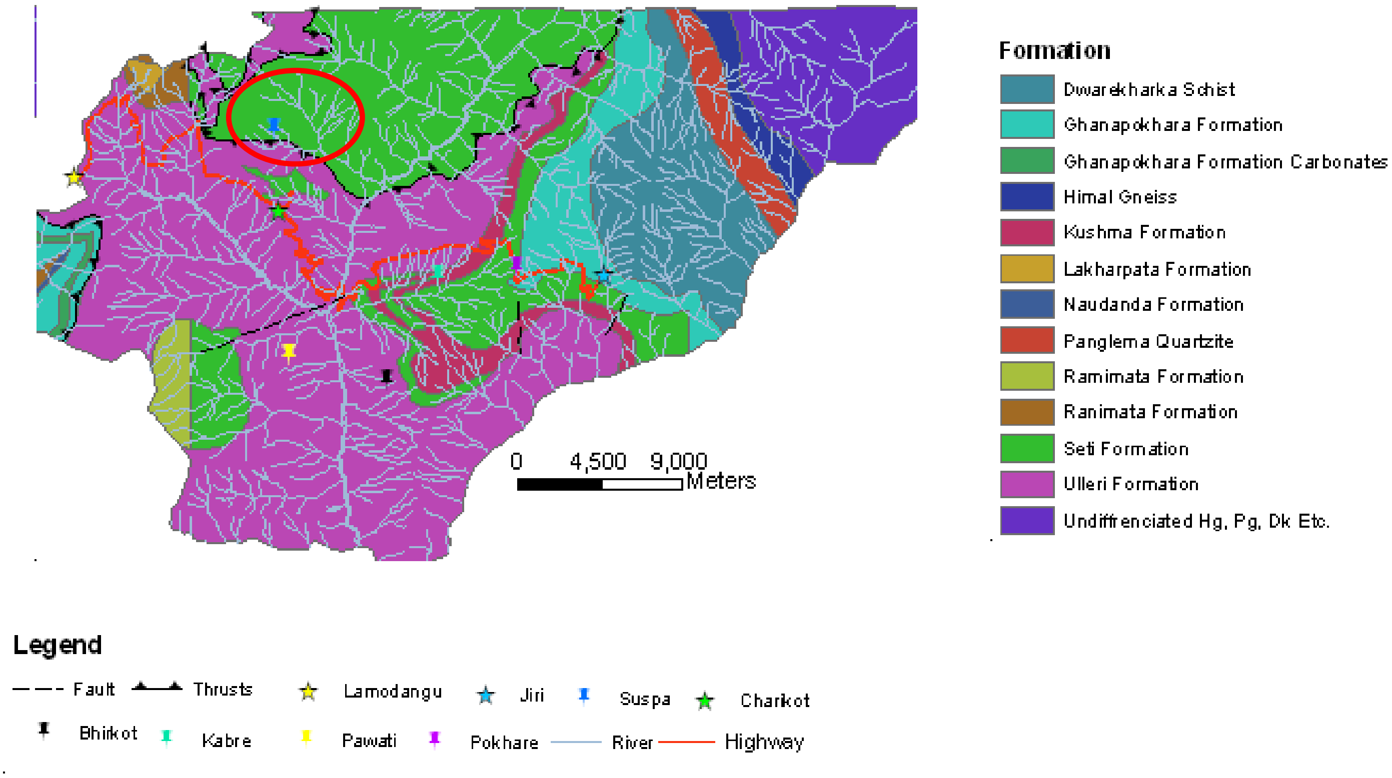


Figure 81. Geological map, Dolaka district (Devkota et al. 2011)

Figure 82. Top left: landslide area, Oct. 2010 (Jaquet, 2010); top right: landslide area *Uttis* trees (Jaquet, 2010); bottom right: stairs leading up from road constructed in April 2010; bottom left gabion wall constructed in April 2010. October 2010

Thang thang /Gairithok social context (Figure 83)

- Low status indigenous ethnic group (*Thami*), with low food security, small landholdings, few remittances and largely illiterate;
- Because of slowly moving land, much land was converted to growing maize, instead of more valuable rice;
- Houses are usually 2-storeys, with separate barns and outdoors pen for livestock, however most are cracked;
- There is one primary school in the village and a secondary school 30 min. walk above the village;
- The village has easy access to a well-travelled all season earthen district road;
- A very poorly organized village, as nobody was aware that one of their community members sits on the CFUG committee and attends meetings. The representative neither reported about the meetings, nor asked for input.
- The canals are a subject of great contention. According to village elders, they were built illegally over 40 years ago, after an earlier irrigation canal collapsed;
- Twenty years ago, five persons died after a debris flow destroyed two houses due to heavy rainfall,village residents are afraid that history will repeat itself;
- According to respondents, the upper caste *Siwalkoti* community has come to dominate the *Thami* community by becoming their land owners as the *Thamis* became indebted and repaid their debts with land;
- Over time, the *Siwakotis* have come to own 2/3 of the Thang thang /Gairithok village, with the *Thamis* working as day laborers, obtaining half the yield as payment;
- The Thamis claim to have sought retribution for the irrigation canals and seek assistance from district authorities, to no avail, as they did not file any official complaint;
- As illiterates, they are very unsure of themselves, their rights and to whom they can turn for assistance.
- They have received some support from a small NGO 'ETC' to support school children with school supplies, agricultural outreach and women's savings groups and install two biogas systems;
- The women have formed a group for pooling savings and providing support to the most marginalized families.
- A few households are members of the local milk cooperative as they are the only ones with enough excess milk for sale;
- Community members assist each other with house construction or other needs but they have no community leader and do not hold regular meetings;
- Some signs of alcohol abuse were observed.

Causes of landslide

- A majority believed that the landslide was caused by "weak geology", especially seepage from the canals, underground water and heavy rainfall, combined with anger from the Gods;

Coping strategies

- Half of all households have moved their houses when they become too cracked to new locations within the village, incurring significant cost;
- Only a few families have family members who have migrated and send home regular remittances;
- There is a sense of resignation in this village as people seem forced to accept their fate and position in society.

Risk perceptions

- Risk perception is considered very high as depicted by the community's risk map, where all houses except for seven are considered at the highest risk by the population (Section 5.2.3);
- Women corrected the men's initial map by insisting that more houses be considered at high risk;
- The irrigation canals are perceived as extremely dangerous, an opinion shared by officials at the Soil and Water Conservation District office (pers. comm, 2010).

Textbox 8

Figure 83. Top left: biogas installation; top right: Thami children; bottom right: crack house; bottom left : Thami house. October 2010.

5.2.2. Social context: Participatory exercises

A similar social mapping exercise was undertaken in Thang thang /Gairithok in order to map community priorities, risk perceptions, resources needed for everyday life, threats to the village and linkages between resources a participatory "social mapping" exercise was undertaken with men and women separately. Figure 84 illustrates the women's social mapping exercise conducted by the women focus groups in the two communities. Focus group participants were first asked to list resources, group them, name the groups, link the various resources and rank them. As the women are illiterate, sketch drawings were made on post-its by one of our team members and were approved by the women. The women then reorganized the 'post-its' into groupings that they defined and named (Figure 85). Five categories were identified: 1. Basic needs; 2. Insecurity; 3. Insecurity; 4. Resources needed to move forward; 5.Access to land. The most difficult part of this exercise for the women was to rank the five groupings. They decided that the last three were equally important and could not rank them. Threats came out of this exercise, with health problems coming first, followed by landslide, heavy rain, social threat from the landowners, Siwalkotis and the lack of access to land.

Figure 84. Left: men's participatory mapping exercise; right: women's social mapping exercise, October 2010.

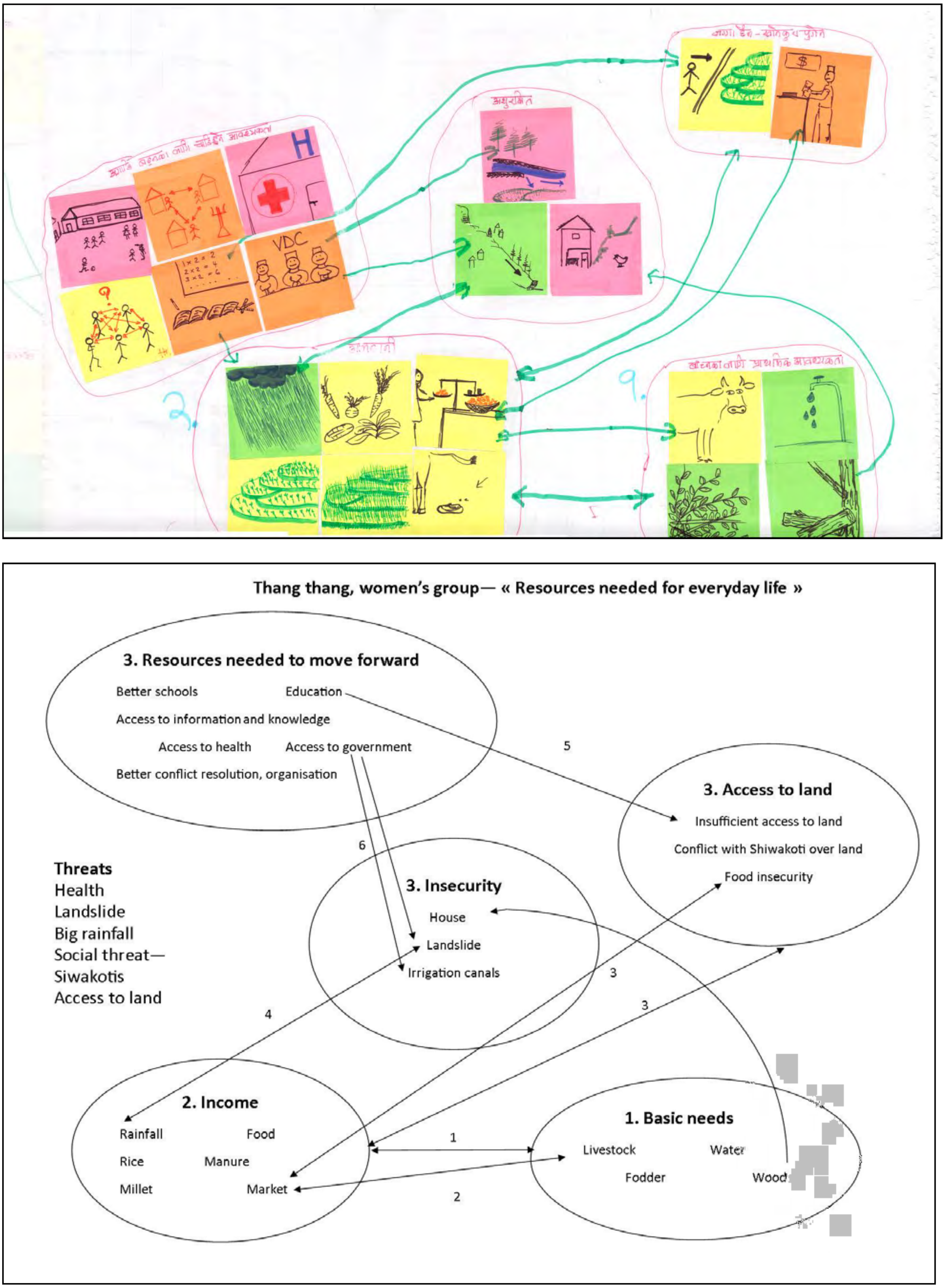


Figure 85. Top: women's social map; bottom social map translated. Numbers in ovals represent priorities; numbers on arrows represent the order in which linkages were drawn. Note that some arrows are one-way and some are two-way. October 2010.

Figure 86 illustrates the men's social mapping exercise, this time using a mix of keywords and sketches as some of the men were literate to map "resources needed for normal village life".

The men prioritized resources as follows:

1. Education and skills training for generating employment, improving health and information sharing;
2. Social relations, social harmony needed for many things such as taking care of sick people and agriculture;
3. Physical structures for mitigation of landslides in order to better develop projects;
4. Natural resources to mitigate the landslide and improve water and income generating resources;
5. Income and resources through skills training, education and improvements in agriculture.

Thang thang, men's group— « Resources needed for normal village life »

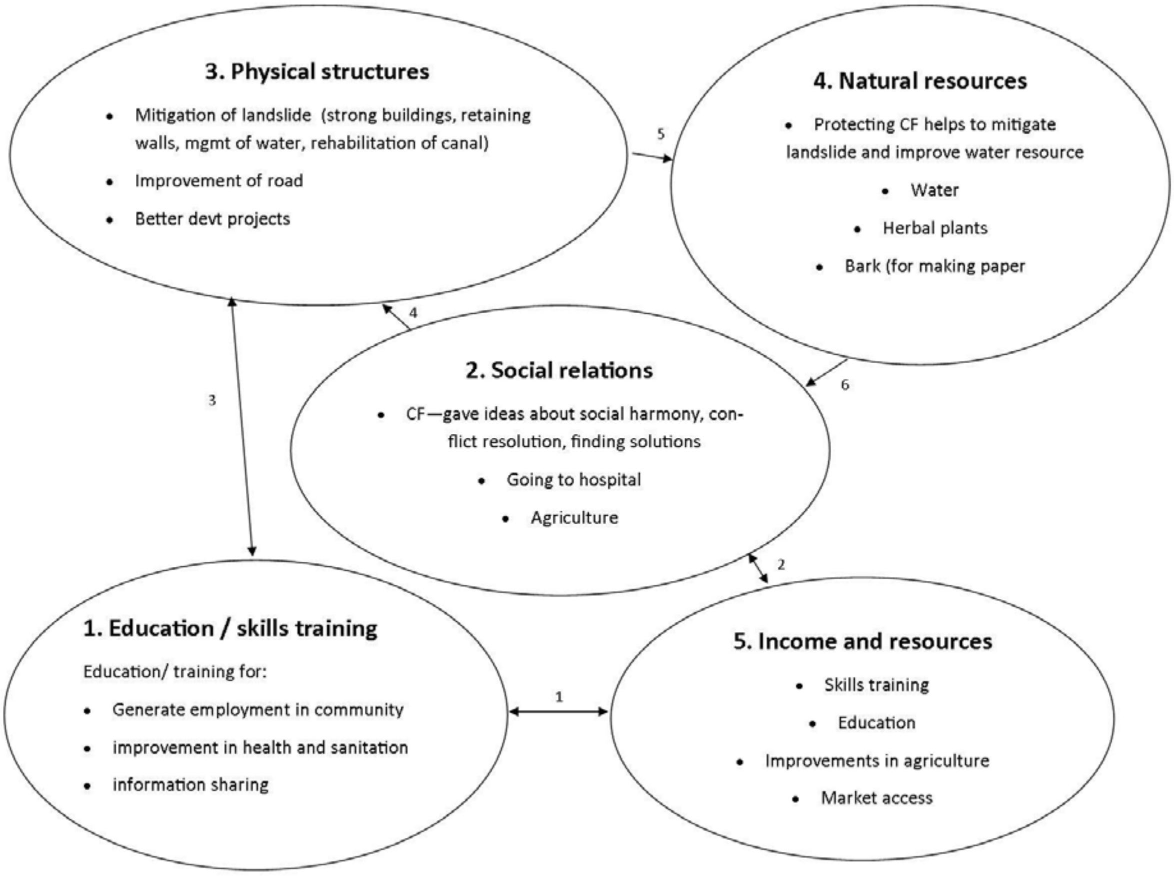


Figure 86. Top: men's social map; bottom: translation. Numbers on arrows represent the order in which linkages wehre made. Some arrows are one-way only and some are two-way. October 2010.

The last exercise was: 'resources needed for during disaster or an emergency' (Figure 87). The exercise was more difficult for the community as they had never thought about organizing themselves in the event of an emergency. They obviously prioritized saving lives and interestingly identified their notion of an emergency, which includes the need for food, mediation with the dominant community (*Siwalkoti*), resettlement of the community and health. For this they realized they needed government assistance.

Thang thang/Garitok resources needed during disaster

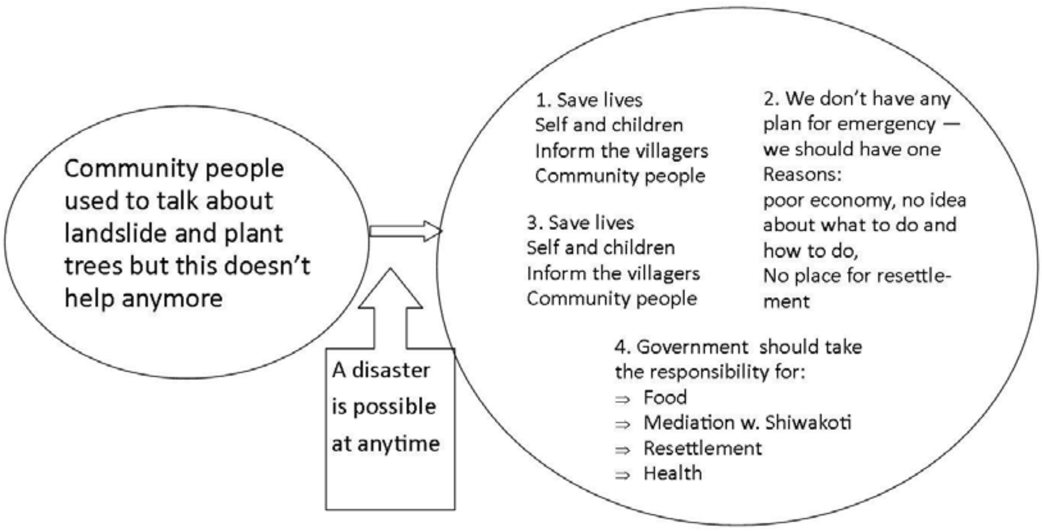


Figure 87. Top: resources needed for emergency; bottom: translation. October 2010.

Figure 88 shows a drawing made by *Thami* children, who had been given a poster size blank sheet of paper and asked to draw whatever they liked. They drew their school several times, adorned by flags, and mountains, symbolizing the importance placed on education by this village.

Figure 88. Drawing by Thami children of their school. October, 2010.

5.2.3. Risk assessments

5.2.3.1. Participatory risk map

After initial presentations and an explanation on our behalf about the purpose of our visit to the community. We requested permission to survey households and examine the landslides and cracks. The first exercise was a participatory risk mapping exercise with both women and men. Two of the most qualified men were selected by the group to draw the map after discussion and hesitation. The self-designated map makers were given a large sheet of paper (A1), colored pencils and asked to draw the main features of their community, with houses colored in red for most at risk, orange less at risk, and yellow least at risk.

The resulting map (Figure 89, Figure 90) presents a high level of risk for most houses of the community, partly explained by a previous incident twenty years ago when five persons died after a debris flow destroyed two houses due to heavy rainfall. Now the residents were very concerned that history would repeat itself. Risk perception was considered very high, where all houses except for seven were considered at the highest risk by the population. Women corrected the men's initial map by insisting that more houses be considered at high risk. The irrigation canals were perceived as extremely dangerous, an opinion shared by officials at the Soil Conservation District office (pers. comm, 2010). Under heavy rainfall, the canals often overflowed and seepage from the un-cemented canals could cause a debris flow. One of the canals was situated directly above the landslide scarp. All trails which would enable evacuation passed through the landslide area and across the creeks, thus respondents often mentioned their feeling of being "trapped". Other important features mentioned were the sacred tree, the school, the temple and rock quarry.

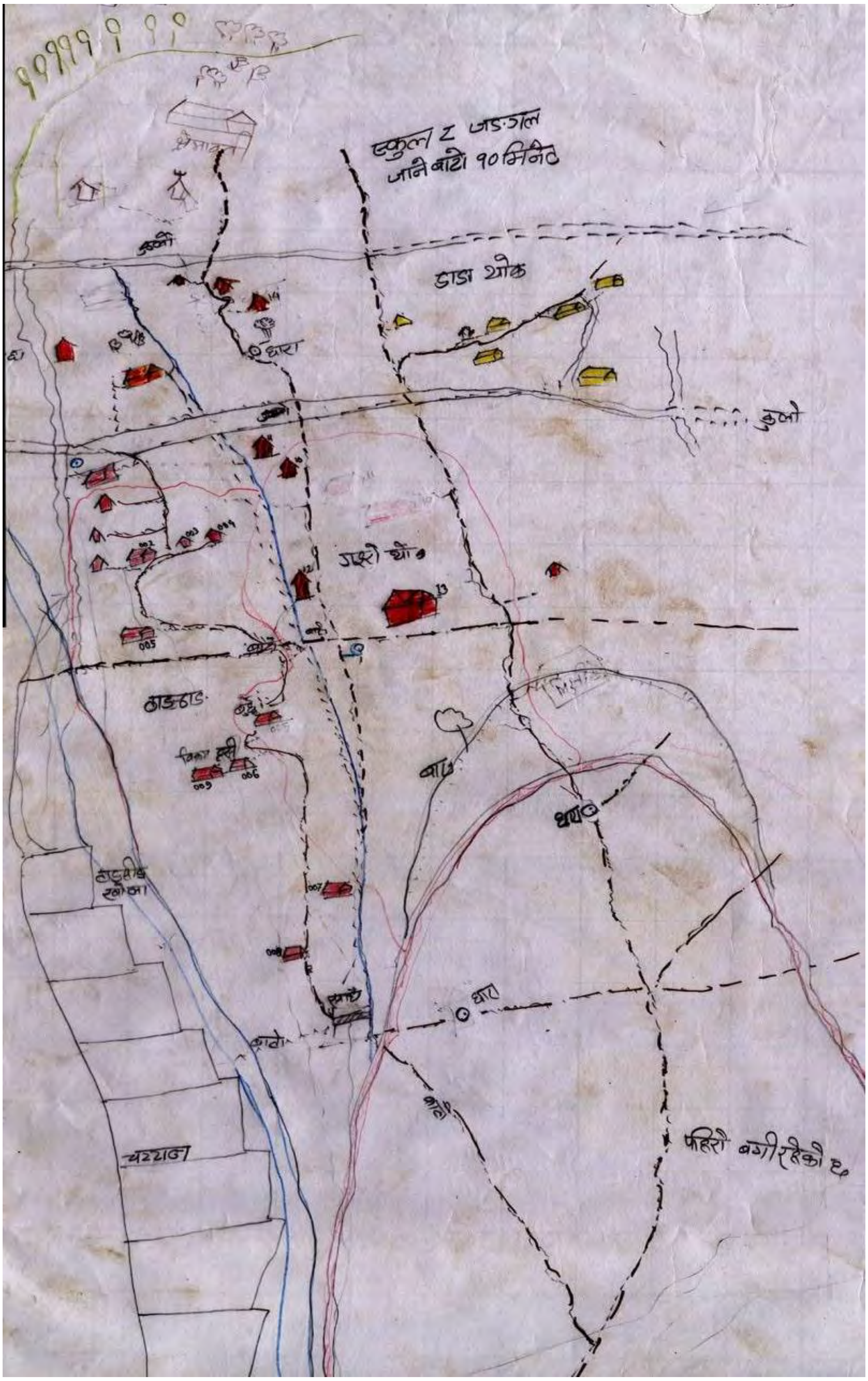


Figure 89. Thang thang participatory risk map. October 2010.

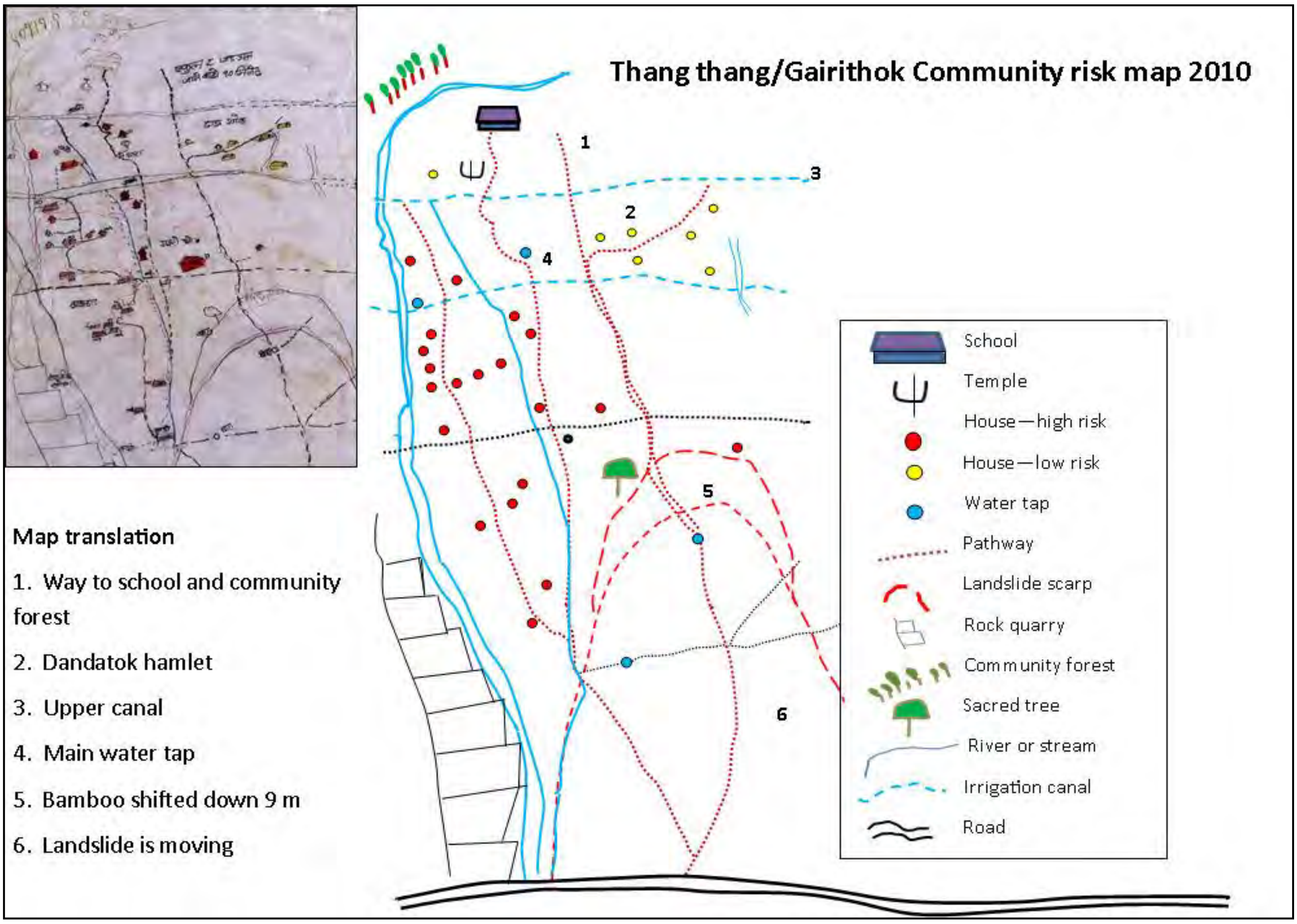


Figure 90. Thang thang participatory risk map, translated with legend. October 2010.

Figure 91 illustrates the same map but transferred to a GIS map for better comparison with following risk maps. Again, we see that all houses are considered at very high risk, except for 3 for which risk was not determined, in one house high up on the hill above the irrigation canal. The reasoning for this high risk was that people feel trapped during high rainfall as there are torrents on each side of the village, with a landslide below it through which most of its trails pass. In other words, during a high rainfall event and in the event of landslide evacuation would be very difficult.

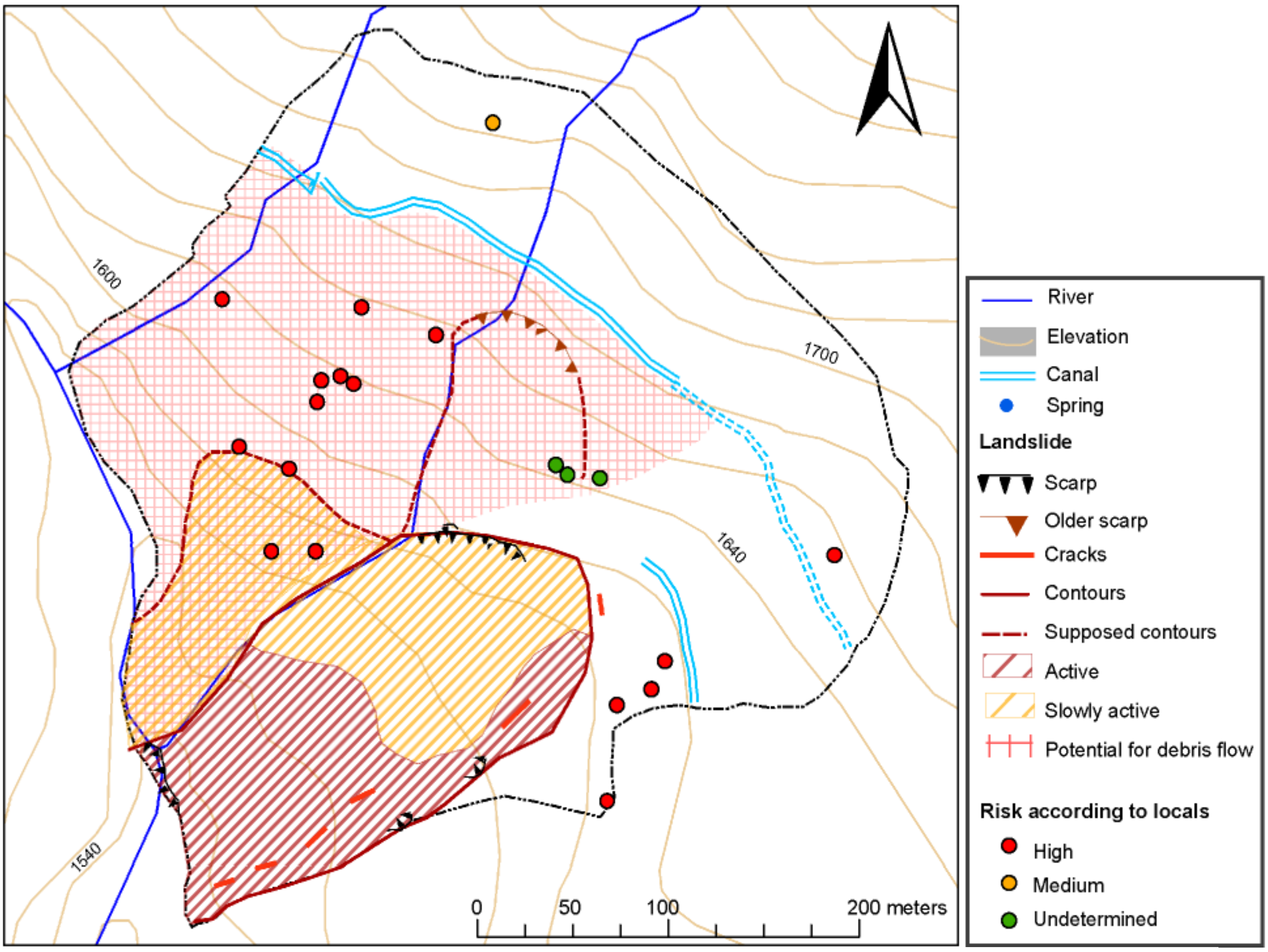


Figure 91. Risk map according to community, Thang thang (Jaquet, 2011b)

5.2.3.2. Geologist's risk map

Our team's geologists considered that there are two different hazard situations for this village, one is the upper debris flow area, the second is the lower landslide area (Jaquet, 2011b). According to the population the last debris flow to affect the village was about 25 years ago, so a return time of 25 years (0.04) has been chosen for the debris flow area (Table 26). Also according to the population, the landslide occurred approximately 20 years ago, most likely due to earthquake activity and/or heavy rainfall, as the area is crossed by a fault line as part of the MCT thrust. Scars from past events were visible in the middle of the village and by the river but it was not possible to determine when these occurred more accurately.

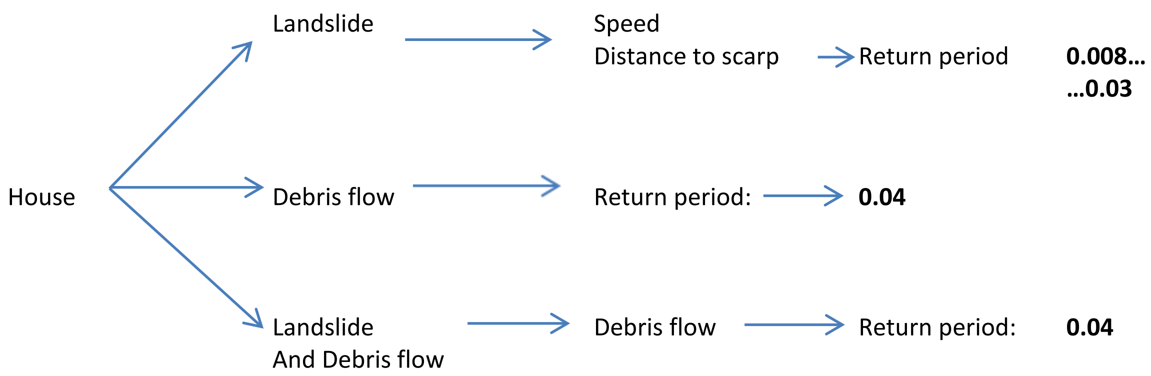


Figure 92. Methodology for determining the hazard in Thang thang (Jaquet, 2011b)

According to our team's geologists, 11 households, or approximately half are at high risk (60.5 casualties within 50 years) especially from debris flow, with a high probability of occurring during high monsoonal rains and seepage from the irrigation canals (Figure 93). There are three houses at medium risk and six at low risk. There is therefore quite wide range of probability of a debris flow or landslide, between 21%-70% within 50 years (Table **27**).

Id	Description	Risk local	Distance [m]	Vulnerability (V)	Exposure (E)	Loss (W)	Hazard (H)	Risk (R)
4	House	middle	207	0.2	0.1	5.5	0.008	0.00088
14	House	high	131	0.2	0.1	5.5	0.011	0.00121
10	House	high	36	0.2	0.1	5.5	0.03	0.0033
11	House	high	40	0.2	0.1	5.5	0.03	0.0033
12	House	high	23	0.2	0.1	5.5	0.03	0.0033
13	House	high	46	0.2	0.1	5.5	0.03	0.0033
878	House	undetermined	42	0.8	0.1	5.5	0.04	0.0176
879	House	undetermined	38	0.8	0.1	5.5	0.04	0.0176
880	House	undetermined	42	0.8	0.1	5.5	0.04	0.0176
2	House	high	48	0.8	1	5.5	0.04	0.176
3	House	high	55	0.8	1	5.5	0.04	0.176
4	House	high	56	0.8	1	5.5	0.04	0.176
5	House	high	38	0.8	1	5.5	0.04	0.176
6	House	high	1	0.8	1	5.5	0.04	0.176
7	House	high	4	0.8	1	5.5	0.04	0.176
8	House	high	0	0.8	1	5.5	0.04	0.176
9	House	high	2	0.8	1	5.5	0.04	0.176
1	House	high	91	0.8	1	5.5	0.04	0.176
2	House	high	99	0.8	1	5.5	0.04	0.176
3	House	high	77	0.8	1	5.5	0.04	0.176

Table 26. Data for estimating "geologists" risk in Thang thang (Jaquet, 2011b)

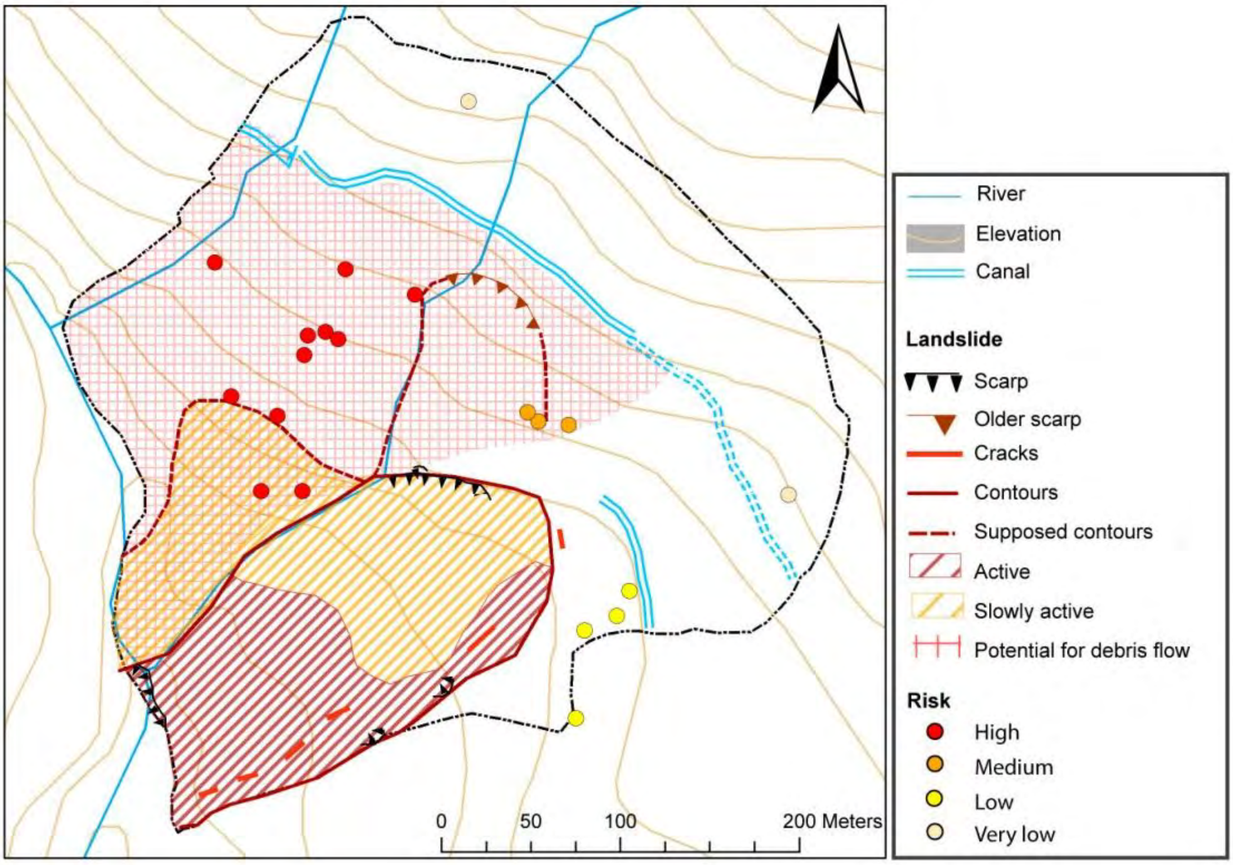


Figure 93. Geologist's risk map, Thang thang (Jaquet, 2011b)

Class	Timeframe	No. of houses (casualties)
High	Within 50 years	11 (60.5)
Medium	50-100 years	3 (16.5)
Low	100-200 years	4 (22)
Very low	200 + years	2 (11)

Table 27. Thang thang risk predictions, geologists' risk map.

5.2.3.3 Composite risk map

As in the previous section, a composite risk map was developed to provide a different perspective on risk. Again, the same calculation was used for calculating risk except that the vulnerability scores were replaced by those developed from the household surveys (Table 28). As approximately half of all households were surveyed, the remaining houses were attributed mean values to provide a better basis for comparison between risk maps.

Id	Description	Risk local	Distance [m]	Vulnerability (COMP)	Exposure (E)	Loss (W)	Hazard (H)	Risk (COMP)
4	House	middle	207	0.78	0.1	5.5	0.008	0.0034
14	House	high	131	0.72	0.1	5.5	0.011	0.0043
10	House	high	36	0.84	0.1	5.5	0.03	0.0139
11	House	high	40	0.82	0.1	5.5	0.03	0.0135
12	House	high	23	0.76	0.1	5.5	0.03	0.0125
13	House	high	46	0.81	0.1	5.5	0.03	0.0133
878	House	undetermined	42	0.75	0.1	5.5	0.04	0.0165
879	House	undetermined	38	0.78	0.1	5.5	0.04	0.0172
880	House	undetermined	42	0.78	0.1	5.5	0.04	0.0172
2	House	high	48	0.78	1	5.5	0.04	0.1716
3	House	high	55	0.70	1	5.5	0.04	0.1540
4	House	high	56	0.73	1	5.5	0.04	0.1595
5	House	high	38	0.78	1	5.5	0.04	0.1705
6	House	high	1	0.83	1	5.5	0.04	0.1833
7	House	high	4	0.84	1	5.5	0.04	0.1852
8	House	high	0	0.78	1	5.5	0.04	0.1705
9	House	high	2	0.78	1	5.5	0.04	0.1705
1	House	high	91	0.78	1	5.5	0.04	0.1716
2	House	high	99	0.78	1	5.5	0.04	0.1716
3	House	high	77	0.78	1	5.5	0.04	0.1716

Table 28. Data for composite risk map. (Modified from Jaquet, 2011b)

Figure 94 illustrates the composite risk map, with the same number of high risk buildings, but a higher number of medium risk buildings, reflecting the fact that families on the southern flank of the landslide, although somewhat less exposed, are composed of one single woman with leprosy, one window and other very poor families who are extremely vulnerable. This vulnerability did not appear in the geologists' definition of risk . According to the composite calculation of risk, we find 11 households at high risk, 7 at medium risk and only two at very low risk within the next 50 years (Table

29). Both the geologist's and the composite risk maps are quite different from the local risk map, which reflects the highest level of risk for all houses. It may be possible that this high local estimation of risk is due to very high perception of risk, an exaggeration to attract outside interventions, or an oversight of geologists' estimates.

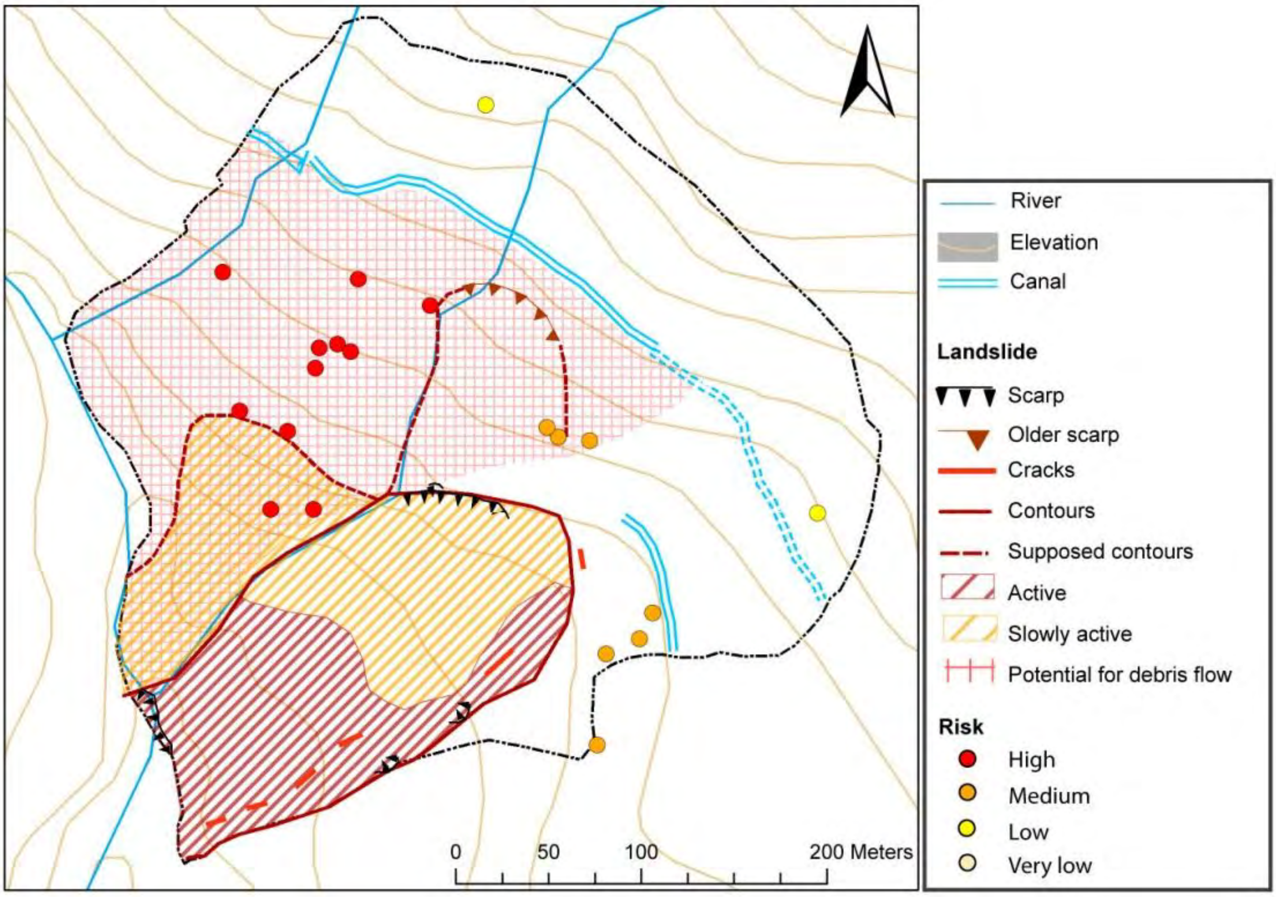


Figure 94. Composite risk map, Thang thang. (Map by Jaquet et al., 2011c)

Class	Timeframe	No. of houses (casualties)
High	Within 50 years	11 (60.5)
Medium	50-100 years	7 (38.5)
Low	100-200 years	2 (11)
Very low	200 + years	0

Table 29. Thang thang risk predictions, composite risk map.

5.2.4. Synthesis and discussion

Regarding the landslide and possible debris flows, ground and overland flow of water should be managed to reduce landslide movement. It would be best to replace the cultivation of rice that requires more water and drain springs and surface water properly. One of the most urgent activities is to entirely cement the irrigation canals. Bamboo and other trees having longer roots are recommended for this area. The aim of the mitigation measures should be to make the area dry first, then bio-engineering works in the upper part of the landslide should be encouraged that can help to stabilize the agricultural land (Devkota et al., 2011). Secondly, to increase safety, the village needs to establish an evacuation plan that includes the construction of a bridge permitting villagers to cross raging torrents during heavy rainfall.

Regarding the social context, the main difference between the two communities in case study 1 and 2 is differing levels of coping strategies and access to resources. The high-caste and richer community, Khariswara has collectively been seeking external assistance by turning to the media and government agencies, while considering relocating the village elsewhere. Main risk priorities and coping strategies in marginalized Thang thang /Gairithok are focused on food security with some monitoring of the landslide and irrigation canals, while praying for safety. The situation in Thang thang /Gairithok underscores the social constructivist theory of risk, where risks are appropriated and accepted as part of everyday life (Wynne, 1996). The passivity of Thang thang /Gairithok may be typified by Douglas and Wildavsky (1982) as "fatalistic" where seeking external assistance is considered futile: *"We do not have the gift of the tongue like the Siwalkotis."* The *Thamis* have little confidence in their own ability to speak up, especially to government officials and no knowledge about their rights. Burton et al. 1993 typifies these coping strategies as "deny risks", with the caveat that the *Thamis* acknowledge the existence of landslide risk, accepts it while prioritizing and concentrating their efforts on food security. Explanations are primarily the low social and economic status of the community, low access to resources and the more chronic versus acute nature of the landslide. A final difference was noted between the two female groups: the *Chhetri* women in Khariswara were more conservative in expressing their priorities and perceptions of risk, compared to the *Thami* women in Thang thang /Gairithok, consistent with ethnographic studies of these groups (Bista, 2004; Gaborieau, 1995).

5.3. Case study III. Katahare village

Katahare Village Fact sheet	
Village location	**Barahachettra VDC** 26°83'05''N, 87°19'53''E 350-450 m.a.s.l.
Average annual rainfall	2000 mm
Surveyed population	n= 30, ca. 35 persons in focus group discussions
Population size	70 households (ca. 350 persons)
Average household size	5.1 persons
Occupations	Farmers, stone quarrying, black smiths, police men, migration abroad.
Average loss due to landslide	ca. 50% of houses damaged and rebuilt; ca. 50% have lost some land
Geology	Middle Siwalik formation Weathered sandstones, Poor soil cohesion Good soil productivity in lower part of village
Land use	Mainly rice, millet, vegetables and tropical fruits.
Average age	26 years
% families with one member abroad	26 %
% families receiving remittances	20%
Ethnic group	*Rai* 67% (indigenous "middle status"), *Dalit* 43% ("lower status")
Average land holding	0.12 ha
Literate	23%
Average food supply	3.2 months
Average % mobiles	36%
Electricity %	0%
Good sanitation facilities*	9%
Community priorities	Access to road, improved agricultural techniques and landslide stabilization methods.

Table 30. Katahare Village Fact Sheet

Katahare Village	**Barahachettra VDC, Sunsari district** 26°83'05''N, 87°19'53''E
Surveyed population and methods September 2008 September 2009	n= 30 questionnaires in 2008 ca. 35 persons in two focus group discussions in 2008 and 2009; Risk mapping exercise in 2008 Google Earth satellite images 2004 Topographic sheets 1:10,000

Table 31. Katahare village, research methods

5.3.1. Overview

The second region of study lies east of the Koshi river at the foothills of the terai plains (Figure 95, Figure 96). The Koshi River basin is one of the mightiest in the world, the third river of Nepal and a major tributary of the Ganges. It is commonly callef the "sapta Koshi" because its catchment area is drained by seven major rivers, spanning 66,400 sq km, of which more than half originates in Tibet. It is one of the major transporters of sediment in the world, estimated at 94.9 million m3 per year, with an estimated discharge rate of 362 m3/sec in March to 4,729 m3/sec in August (Sah, 1997).

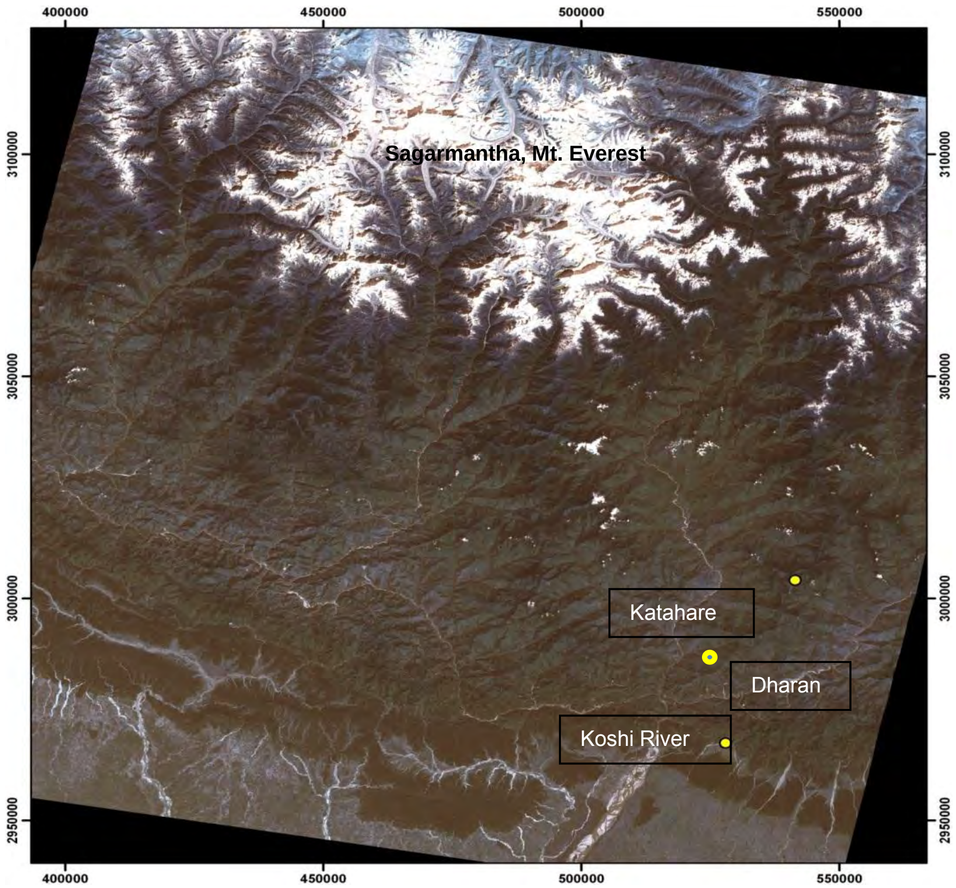


Figure 95. Landsat image of Koshi River Basin, Nepal, 2000/ ICIMOD-Nepal

The Koshi is infamous for its unpredictability and meandering, braided floodplain, due to the high sediment rates, the river has changed course over 150 km in the past 200 years. The Koshi dam, built by India in 1962 to reduce flooding in Bihar state, is located approximately 30 km west of Dharan and is a major supplier of electricity to the region. Dikes built along Koshi's banks are meant to protect neighboring Nepali communities and ensure more stable livelihoods. The dykes, maintained by the government of India did not hold up due to sedimentation fill up and poorly maintained dykes.

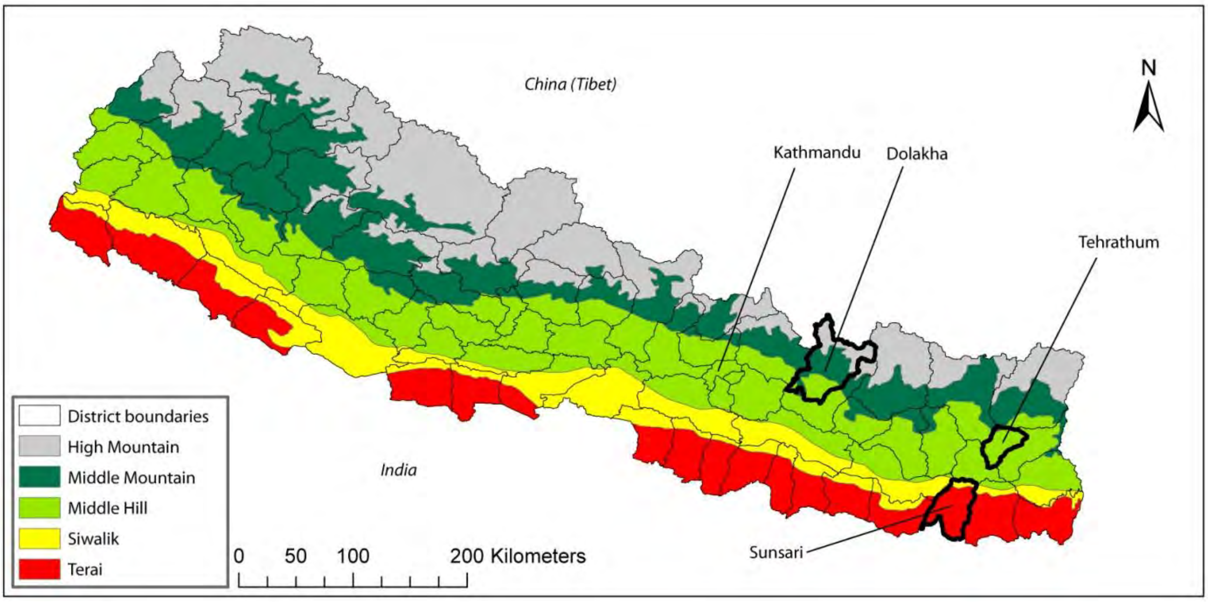


Figure 96. District map Central and Eastern Nepal with survey sites. Jaquet, 2011b

On August 18, 2008, a dyke on the right bank north of the barrage broke, killing hundreds and displacing millions in Nepal and Northern India (Figure 97). The Koshi River is thus a dominant feature of the region and much of its land use history and geography are shaped by it.

Figure 97. Left: Koshi River dyke breach seen from airplane; right: Point along dyke where breach occurred. September, 2008.

The second dominant feature of this region is marked by the Main Boundary Thrust (MBT), which separates the Siwalik hills from the lower Himalaya. This uplifting movement has led to a number of large and minor earthquakes, notably the Bihar earthquake in 1934 (ca. 8 on Richter scale) and the 1988 earthquake near Dharan (6.8 on Richter scale), which in their turn triggered numerous landslides and leaving tension cracks which are still active today. Twenty kilometers east of the Koshi River in the first foothills of the the Siwalik hills lies Katahare village, case study site III. The selection of Katahare was made based on a recommendation by our host organization (IUCN Nepal) due to observed vulnerability of populations and acute landslide problems.

Katahare village (Barahachettra VDC, Sunsari District),with a population of approximately 325 persons in 65 households, is situated at 450 m.a.s.l., just above the Bagh River on top of steep slopes (approximately 35-50°) on the border between Terai and the first foothills of the *Siwaliks*. The village lies 15 km west of Dharan and is accessible via jeep roads, with the last 800 m only accessible via a bridal path. It takes the local population approximately 25 minutes to reach the road, where frequent transportation to Dharan is available. For those who cannot afford public transportation, the walk to Dharan takes approximately 1,5 hours. A majority of households have at least one person who commutes to Dharan for work or schooling. Katahare has one primary school, no health facilities or electricity. There are three pumps, which provide drinking water.

The Bagh River, which flanks Katahare village, is a tributary to the Koshi River, approximately 5 km to its east (Figure 98, Figure 99). It has been causing flooding to nearby communities, especially lowlying Punarbas for decades and is known for its unpredictability (Bagh means tiger). The local authorities have been trying to manage its banks for the past 14 years, resulting in massive flooding of the community forest area, but with reduced flooding to Punarbas. Upstream, rock collectors, some originating from Katahare remove large numbers of boulders, providing their main source of livelihoods. There are approximately 20-30 truckloads of boulders and rocks removed on a daily basis, especially after heavy rainfall when more boulders are available. Rock collectors are also taking boulders from river banks, leaving tree roots barren and severely destroying the river banks.

Figure 98. Bagh River on Katahare's west flank, provides revenue from rock and boulder collection. Sept. 2008

Khariswara environmental context (Figure 99**,** Figure 100**,** Figure 101**)**

- Average rainfall: 2,000 mm;
- The vegetation is tropical, with rice paddies and maize fields alternating with home gardens, where bananas, mangoes, bamboo, ginger, curcuma, pulses and a variety of other crops are grown;
- Katahare is situated in an ancient landslide area. The largest most recent landslide occurred in 1966 after one week of heavy rainfall, resulting in over 13 households being destroyed and abandoned and only 2 households remaining. There were no casualties but the Red Cross provided tents;
- The village belonged to one large landowner, “Mr. Dhikute” who abandoned the land after 1966 and moved to the lowlying area;
- The affected upper part of Katahare became state owned land and people started to occupy the land, migrating from other parts of Nepal due to better access to employment and amenities here.
- One house was rebuilt in the 1966 landslide area by immigrants from Sikkim, India;
- As a result, Katahare is split between the upper part (*Apatar*), settled by mainly landless people, the middle section (*Sarkhilise*) and the lower section (*Sivutar*), settled by an older population, which was not affected by the 1966 landslide;
- *Sivutar* is considered the safer area of Katahare, with larger farms and rice fields and 7 households have land titles for which they must pay a small annual royalty (apprx. 30 Rs per hectare);
- *Apatar* is more subject to frequent landsliding, damaged houses and frequent moving of houses. The village leader, Kumar BK (Dahlit) lives in *Apatar*, and is also the president of the Community Forest User Group;
- The average field size ranges from 1000 m2 - 5000 m2 (15 *katha*) and farmers tend to have their fields spread across the village in various locations;
- CFUG was established 13 years ago and the population can benefit from grass, wood, timber for domestic use not for sale. Forty-four households (2/3 of the village) currently share this community forest and some trees have been replanted;
- Respondents mentioned that illegal logging has decreased since the CF was established. Livestock are mainly kept in pens;
- Proceeds from the CF were used to build a road four years ago from Sabra to Chettra but landsliding in the first rainy season wiped out the road and made it impracticable;
- Funds from the community forest were also used to bring electricity to Katahare and new electric posts have been established for *Apatar* in the past year. However, none of the proceeds are used for investing in managing the forest, reforesting or forest protection, according to respondents.

Textbox 9.

Figure 99. Google Earth image of Katahare, 2004

Figure 100. Top left: Katahare as seen from neighboring village (Dubois/2008); top right: Koshi River as seen from Katahare; middle right, house in lower part of the village; bottom right: house in upper part of village; bottom left: landslide area due to local road building (Dubois/2009); middle left: house and barn in lower part of village. All other pictures from Sept. 2008.

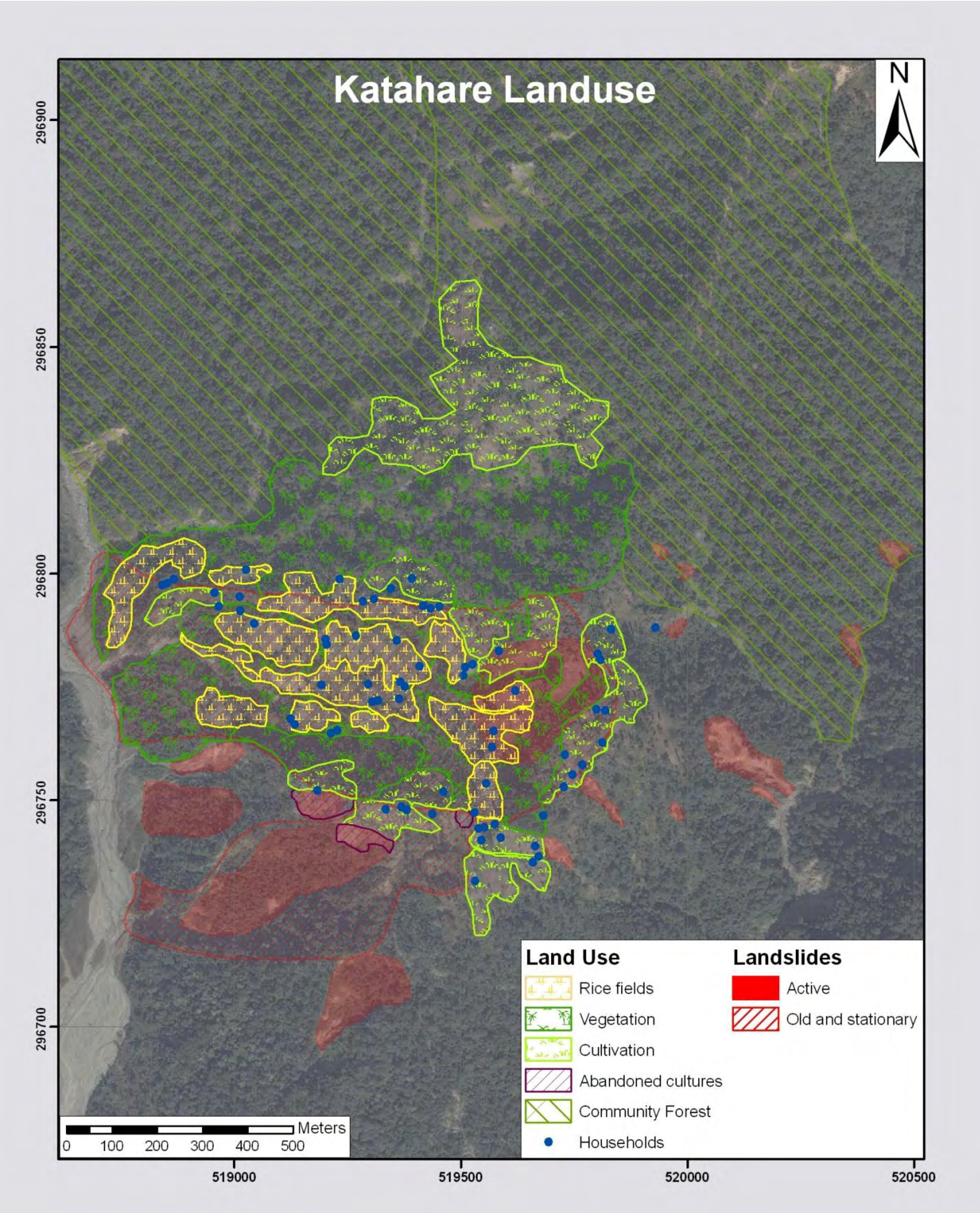


Figure 101. Katahare land use and event map (Paychère and Dubois, 2009)

Katahare geological context (Figure 102)

- The geology is characterizes by weathered sandstones of the Middle Siwalik formation, very sensitive to slope destabilization due to the presence of clays (Duvadi *et al.*, 2001). These sandstones are completely weathered in this region, strongly decreasing their stabilility;
- The village is flanked by two rivers, which are gradually undercutting several slope toes;
- The village-constructed road was built through the 1966 landslide area, and created some instabilities. As a result, several small landslides were triggered, one shed became impracticable and a boulder damaged one home;
- The geomorphological form of the watershed upon which Katahare is based, points to ancient massive landslides having shaped this landscape,making for flatter and more productive terrain in its lower parts.
- Thanks to abundant rainfall and vegetative cover, the population has been able to reconvert the landscape into productive yet in many places, unstable farming lands;
- The current landslide situation here is quite complex, with at least 9 landslides of varying size and velocity affecting most of the village's upper and south sides;
- The village school in particular is situated in a high risk area, just below the 1966 landslide area.

Textbox 10.

Figure 102. Top left, landslide crack below damaged shed due to local road building (Sept. 2008); top right: house below landslide crack, one boulder was dislodged during heavy rainfall damaging this house (Dubois/2008); bottom right: view of school from upper village (Sept. 2009); bottom left: view of land slide area which is still active (Sept. 2009).

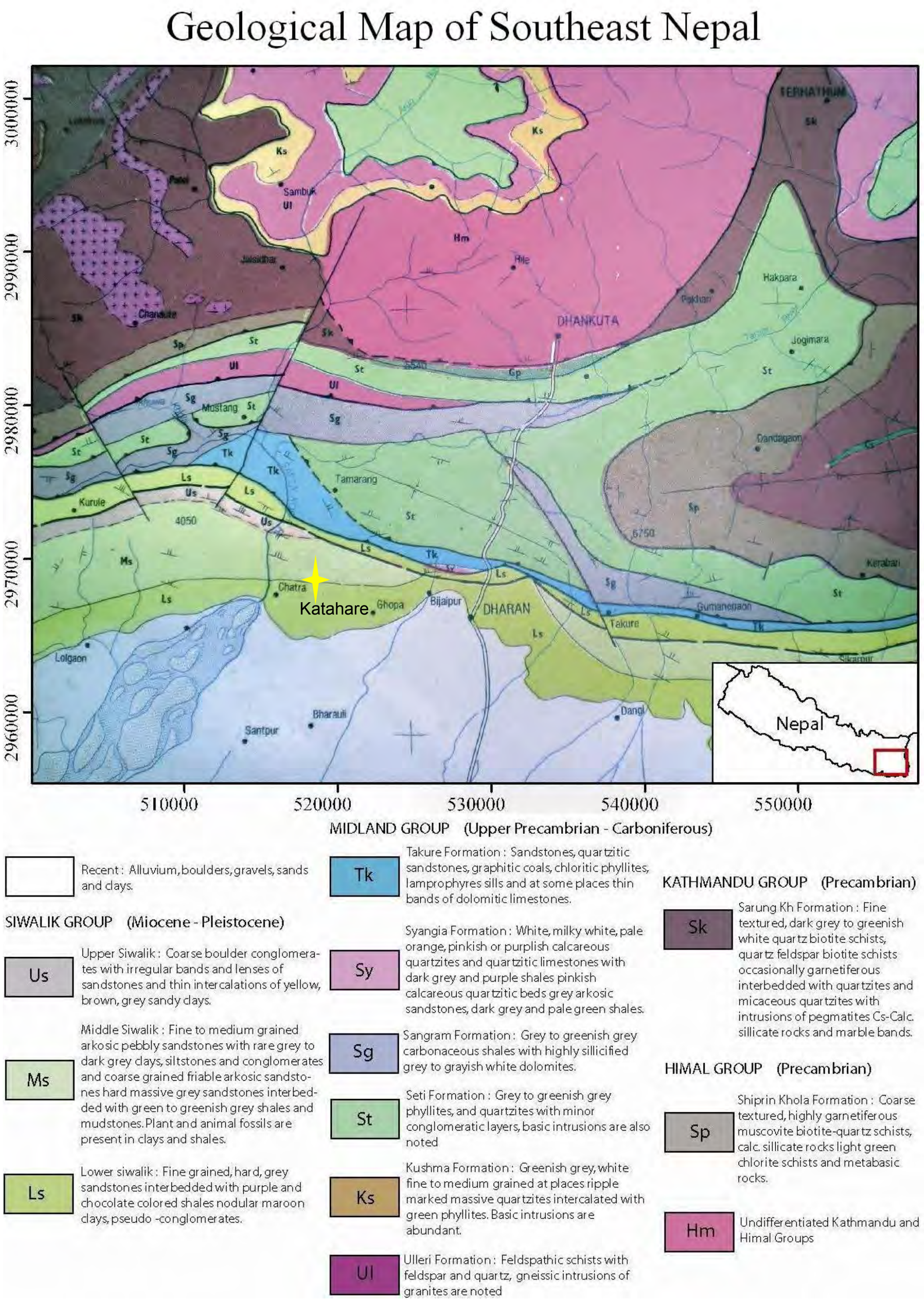


Figure 103. Geological map of Southeast Nepal, Department of geology and mines, Government of Nepal

Khariswara social context

- The village consists mainly of the *Rai* ethnic group, one of the *Jangati* indigenous groups, considered of middle status among ethnic groups and *Dalits*, considered low caste (previously referred to as "untouchables") no conflicts between the two were mentioned;
- The village has one school with students until class 5 (11 years old), after that students must walk 1,5 hour every day to the Chettri/Punarabas area for schooling;
- Occupations differ between Sivutar, the lower part of the village, who are mainly farmers and policemen with larger landholdings, better education and titles to the land, and the officially landless upper Katahare residents in *Apatar* who are stone collectors, (40% of households are stone collectors) and meager farmers;
- There is current disagreement between the residents of *Apatar* and *Sivutar* regarding development plans for the village. *Apatar* residents now have electric posts but they need to have sufficient funds for the down payment of the meters, which they are in the process of acquiring. They believe that *Sivutar* people are not interested in development, nor in access to electricity. *Sivutar* residents however claim that they were not invited to meetings about electricity and have been excluded from this opportunity;
- Otherwise, social cohesion, as determined by mutual assistance for house reconstruction, appears quite strong between *Apatar* residents;
- The new electric posts were erected by *Apatar* residents and go through the 1966 landslide area.
- Stone collection is one of the main employment opportunities in the area, managed by the district government, which reaps 80% of the benefits from this activity, the remainder goes to the local government
- Except for the VDC social worker, no other NGOs have been active in Katahare;
- The CFUG is the only social organization in the village;
- There used to be a women's group in the village but is no longer active, as it appears that the woman leader moved away. The women had some savings for household items and some loans given to needy people.

Causes of landslide

- Most respondents firmly believed that landsliding problems are mainly due to the massive stone collection (stone quarrying) from Bagh river below Katahare, secondly due to the "weak" geological conditions of Katahare and third, anger of Gods;
- The prevalent view that stone collection is to blame for landsliding gave rise to a serious incident where a resident from Katahare was killed in 2008 by one of the stone collectors from a neighboring village near Punarbas. The incident arose over proponents against the stone quarrying, which is clearly affecting the stability of the river bank, and the stone collectors who are working as day labor.

Coping strategies

- The main coping strategy of the affected households, mainly in *Apatar* is to move house location, sometimes 5 m., 25 m. or 100 m. away in hopes that the house will be safer in the new location. These houses remain relatively simple, so easy to reconstruct, yet reconstruction constitutes a drain on the household budget;
- One family emigrated to a village in the terai, only to return last year to be close to their relatives;
- Two families have one family member who migrated to Gulf states and are sending home some remittances.

  Of all respondents, only two families stated that they sleep elsewhere during heavy rainfall;

  They have not sought assistance from government for the landslides.

Risk perceptions

- Respondents have in-depth knowledge of which areas are sliding, the location of cracks and are aware of the dangerous situation of houses on the south and west rims, in accordance with our team's risk assessment. They did not however consider the school to be at risk, even though it lies below an old landslide area and there are some signs of recent activity;
- They are also very knowledgeable about local plants, notably bamboo and "broom grass", which is effective in binding soil and preventing superficial sliding. However most respondents agree that even slopes with trees will slide if the rains are too heavy.

Priorities

- Women's main priorities were access to road. It is 1 ½ hour one way walking distance to go to market, obtain medical assistance and for secondary school;
- In addition, male respondents mentioned improving their yields with improved agricultural techniques and landslide stabilization methods.

Textbox 11.

Figure 104. Top left: man by cracked house; top right: view of Koshi River from top of village; middle right: rice fields (*Khet*); bottom right: focus group discussion; bottom left: community members by school; middle left: house on South side of village.

5.3.3. Risk assessments

5.3.3. 1. Participatory risk map

The first case study area, and first risk mapping exercise was undertaken in Katahare. Participants were self-selected, mainly a group of young men, who then showed their drawing to elders for approval (Figure 105). The exercise took place outside the school and lasted for approximately two hours. Participants were asked to map their village and what was important to them. They made sure to map all households, the temples, sacred trees, the school, water taps, landslide zones and cracks. Houses were not color coded according to risk, but rather according to dangerous zones (Figure 106).

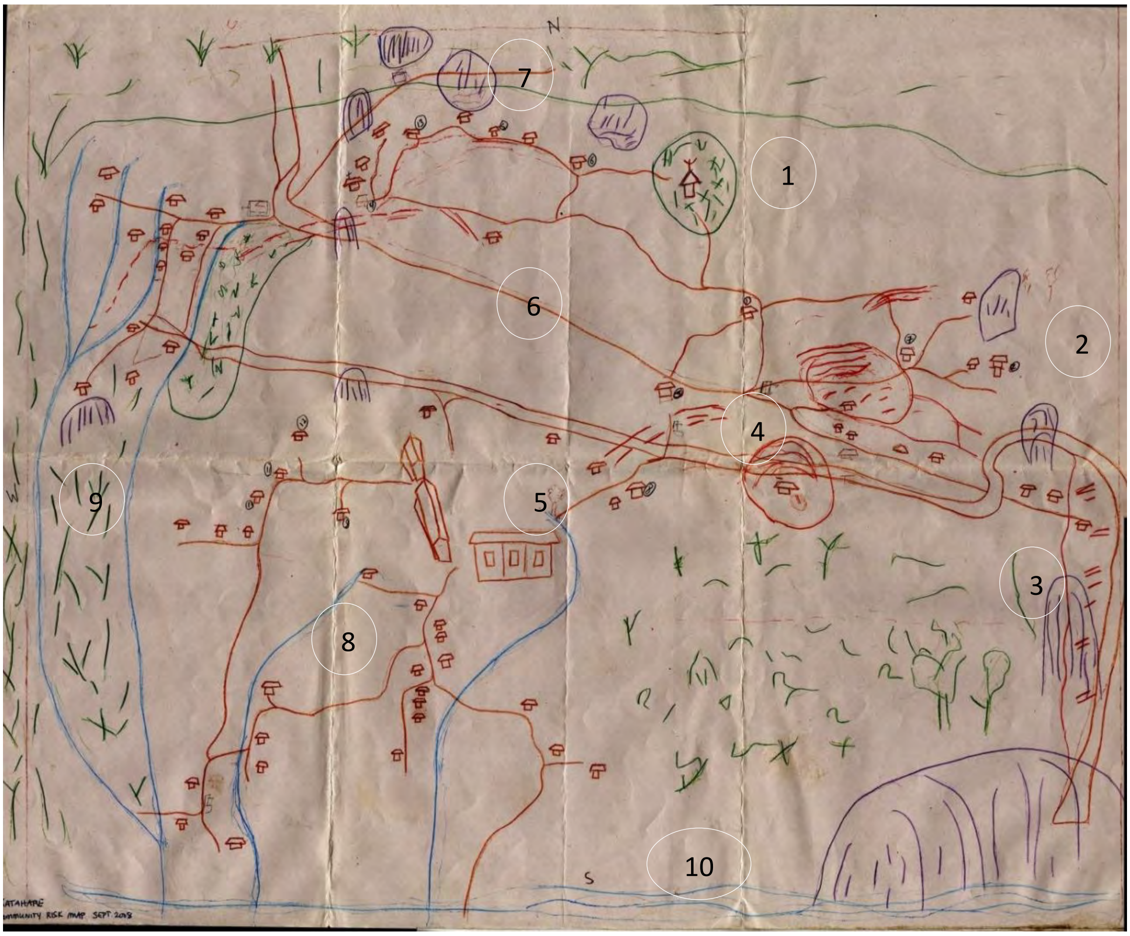
Figure 105. Community risk mapping, Katahare, Sept. 2008

Some comments from respondents:

"We are very afraid of the landslides as we have very limited agricultural land and resources. We have seen so many cracks, and the land structure is not very compact. We have tried planting more trees but there are cracks all over."

"Water enters the cracks and increases the chances of landslides. Cracks are reducing our productivity. Where can we go? We do not have other land to move to. We put compost soil on the land. During the rains, we see all the fertile soil seep into the cracks. 43 years ago is when there was a big landslide, we tried to migrate down to flatter land but the people there didn't want us to settle there."

"We need to learn about agricultural techniques and how to stop the landslides but nobody has come here to provide support and technical expertise."



Map explanation

1. Temple and sacred forest
2. Upper south rim *Apatar* hamlet, active landslide area
3. Purple markings show landslide movement
4. Most affected place, red markings are cracks.
5. School buildings and sacred tree
6. Collapsed road is drawn across map
   Area of 1966 landslide
7. Upper northern part, *Apatar* hamlet, active landslide area
8. Lower northern part, *Sivutar* hamlet, safest area
9. Community forest area
10. Bagh river

Comment: north as depicted by community members is actually east

Figure 106. Katahare Participatory Risk map, 2008

5.3.3.2. Geologist's risk map

Katahare was first village where we can conducted risk assessments. Interestingly, our view of landslide risk evolved considerably from our first visit in 2008 to our second visit in 2009. After our first visit, we were not convinced that this village was at high risk, as few cracks were apparent, and signs of landsliding were not obvious, due to rapid growth in vegetation and this tropical climate in spite of the population's insistence that this is a high risk village. Our opinion changed in 2009 considerably when we were accompanied by Prof. Jaboyedoff, who opened our eyes to signs of landslide movement we had not seen in 2008. We also learned of the existence of a rural road built four years ago by the community with their own revenues generated from the community forest. The road which had collapsed during the first monsoon rain. This relatively new road was already overgrown with vegetation and therefore difficult to recognize, without close guidance by the community and highly at risk. It turns out that the community was absolutely right, Katahare is located in a basin, which was completely formed by ancient landslides. The entire upper part of the village is highly affected by landslide movement, and we later did observe many signs of crack houses and discovered that most of the residents had reconstructed their houses at least once in the past decade.

For Katahare, the concept of relative risk was used, as described in the methodology section in more detail. Risk is thus the multiplication of this destruction potential by the vulnerability and the number of inhabitants (Table 32). For example, a house inhabited by five people, located in an active landslide zone has a maximal destruction potential of 4. The house is considered to be completely destroyed, thus the vulnerability is 1.
The risk is 4 x 1 x 5 = 20 (Dubois and Breguet, 2009)

Id	Description	Vulnerability (V)	Loss (W)	Hazard (Pd)	Risk (R)
	House	1	6	4	24
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	0	0
	House	1	5	0	0
	House	1	5	1	5
	House	1	5	1	5
	House	1	4	1	4
	House	1	4	1	4
	House	1	4	1	4
	School	1	10	2	20
	School	1	10	2	20
	School	1	10	2	20
	House	1	4	1	4
	House	1	6	1	6
	House	1	5	3	15
	House	1	3	3	9
	House	1	6	3	18
	House	1	1	3	3
	House	1	4	2	8
	House	1	5	2	10
	House	1	6	2	12
	House	1	5	3	15
	House	1	5	3	15
	House	1	5	3	15
	House	1	6	3	18
	House	1	5	2	10
	House	1	5	3	15
	House	1	3	1	3
	House	1	5	1	5
	House	1	4	1	4
	House	1	3	1	3
	House	1	4	1	4
	House	1	5	1	5
	House	1	5	3	15
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5

Table 32. Relative risk calculation, Katahare village (Modified from Dubois and Breguet, 2009)

Of a total of 73 buildings, 3 are at high risk (<50 years), including the 3 school buildings, which are situated at the base of the 1966 landslide and housing over 100 students during the school year. Twenty-four houses are considered at medium risk, and the remainder, located in the lower part of the village are considered at low to very low risk. Another building has been classified as high risk, as it is located just below a large tension crack (Figure 107). The inhabitants of this house move to another location when rainfall is heavy. Similarly, under heavy rainfall, cracks above the school should be carefully monitored and the school evacuated if any movement is detected.

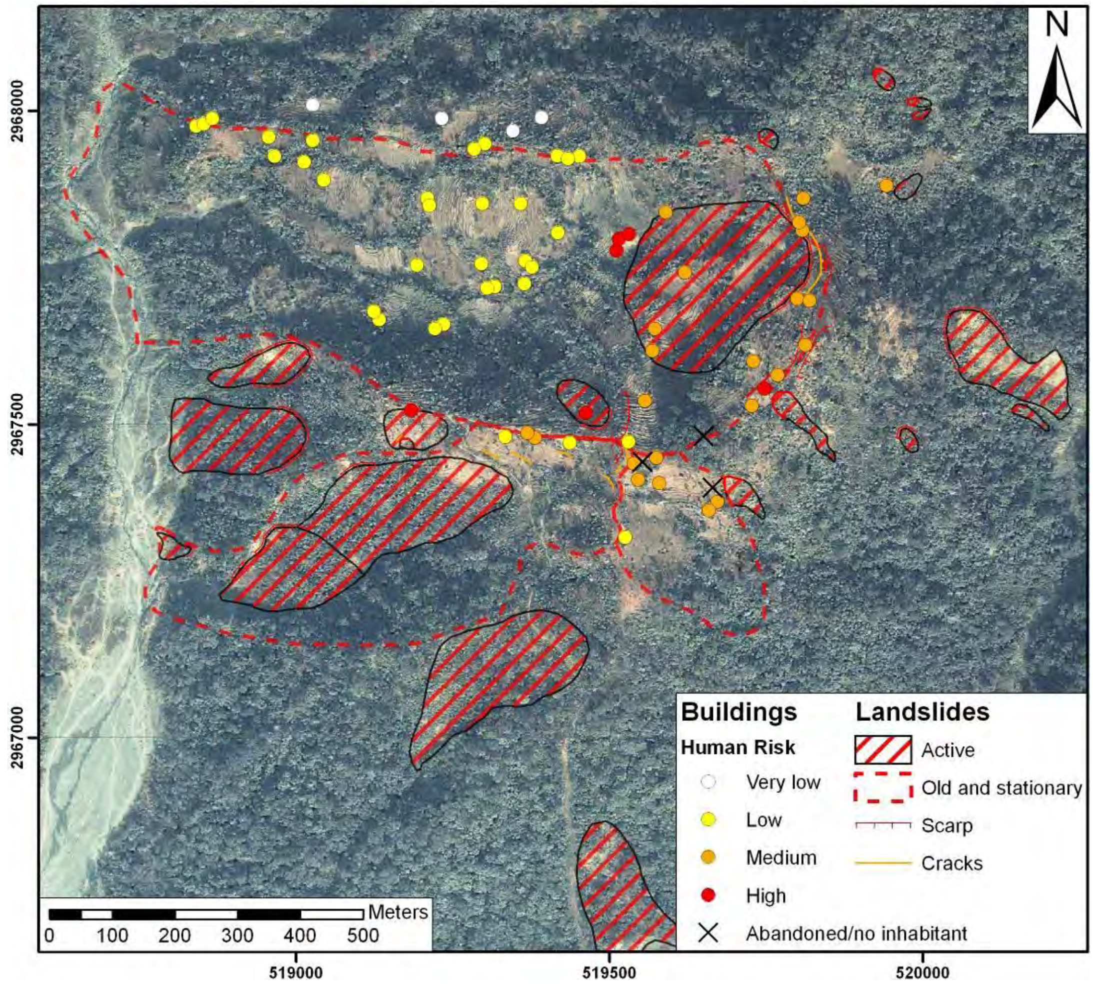


Figure 107. Katahare risk map, (Dubois, 2009)

Class	Timeframe	No. of houses (casualties)
High	Within 50 years	3 (16.5) + school
Medium	50-100 years	24 (132)
Low	100-200 years	42 (231)
Very low	200 + years	4

Table 33. Number of houses and people at risk, Katahare

5.3.4. Synthesis and discussion

A number of houses are at high risk, with at least three households with a high probability of fatalities in the next 50 years, including the school. Another immediate risk is to agricultural land, which is being lost annually and upon which families depend for their livelihoods. Those houses immediately near tension cracks, or whose houses are shifting should be permanently evacuated if possible as high rainfall conditions and a medium-strength earthquake could trigger several landslides. Therefore, priority interventions should include monitoring and draining water away from tension cracks above and below the slope east of the school as water can render slopes extremely heavy.

Secondly, strengthening terraces against erosion and further landsliding can be conducted by combining drainage trenches, with vegetative methods and retaining walls. If possible, investments should be made to secure the jeep road to Chiyabari as it provides access to the village and crosses several landslide zones. Road access is also one of the village's priorities. Possible interventions are to drain water away from this area or to anchor the landslide with supporting piles, using mature bamboo, or metal pile, together with surface drainage. The local population is already aware of which indigenous plants offer the best protection against land sliding: bamboo and broom grass *(Thysamolaena maxima)*, yet one of the obstacles to its further use is the time it takes for bamboo to reach maturity, ca. 8 years. Nonetheless, expanded plantation of bamboo and broom grass, interspersed between terraces and other fruit trees is a cost- efficient method for stabilizing certain slopes.

The cost and labor involved for the community to move and rebuild houses is extremely high, most residents having moved and reconstructed their houses several times. The average stay in the village is 22.5 years, due to in-migration and the average age of houses is only 7 years, due to landslide movement. This expense is one that residents could have instead used to invest in livestock, agricultural improvements or schooling. Although the village has in-depth knowledge of where the cracks and dangerous places are, they continue to live in close proximity to cracks and scarps. Most effective external interventions include technical assistance on landslide mitigation, regulating the stone collection, combined with external support to relocate houses further away from danger zones, agricultural outreach and skills training support.

5.4. Case study IV. Sabra Village

Sabra Village Fact Sheet	
Village location	**Basantapur VDC** 27°13 ’79 ‘’N, 87°40’92’’E 1,800-2,200 m.a.s.l.
Average annual rainfall	2000 mm
Surveyed population	n= 11, ca. 15 in transect walks
Population size	22 households (ca. 120 persons)
Average household size	4.6 persons
Occupations	Farmers, government employees, teacher.
Average loss due to landslide	4 out of 22 houses destroyed ca. 50% have lost some land 8.3 ha lost
Geology	Himal Group, consisting of gneiss, quartzites and biotite schistes, muscovite and quartz. Good soil productivity
Land use	Mainly cabbage, cauliflower, maize, cardamom.
Average age	28 years
% families with one member abroad	54 %
% families receiving remittances	28%
Ethnic group	*Rai* 67% (indigenous “middle status”), *Dalit* 43% (“lower status”)
Average land holding	1.28 ha
Literate	63%
Average food supply	4.5 months
Average % mobiles	36%
Electricity %	100%
Good sanitation facilities*	91%
Community priorities	Stabilize road, employment and landslide stabilization methods.

Table 34. Sabra Village Fact Sheet

Sabra Village	
Surveyed population and methods	n= 11questionnaires ca. 15 persons in transect walks Ikonos satellite image, 2009 Topographic sheets 1:10,000

Table 35. Surveyed population and methods

5.4.1. Overview

Sabra village (pop. 120) is situated 2km north of Basantapur (pop. 4,800) in Tehrathum District, at 2,300 m a.s.l, 90 km by road north of Dharan (27°10´57”N, 87°27´47”) (Figure 109). The road is paved to Dhankuta (60km from Dharan), after this point, the gravel, or mud road is at times barely passable as our visit occurred during the monsoon period. Several roads continue beyond Sabra, the “lower road”, which an earthen road leading to the district headquarters, Tehrathum, constructed approximately 15 years ago; and the “upper road”, heading north to Tapeljung and Chainpur via Mude Sanichhare (Figure 110, Figure 111). The portion from Basantapur to Mude Sanichhare was constructed by the Asian Development Bank and the Nepal Government, starting in 2004, and on-going (IUCN-Nepal coordinator, pers. comm., 2009). The lower road began to significantly subside after the road construction, an important passage way to Tehrathum village, district headquarters. A number of cracks were observed above the road, with a large landslide area below. The wider community of Sabra (encompassing a number of small hamlets), is located in this landslide area 100-300m below the road, with approximately 60 households severely affected, 4 houses abandoned and ca. 5 ha of land lost due to land subsidence of over 40 meters in the past 10 years since the road construction.

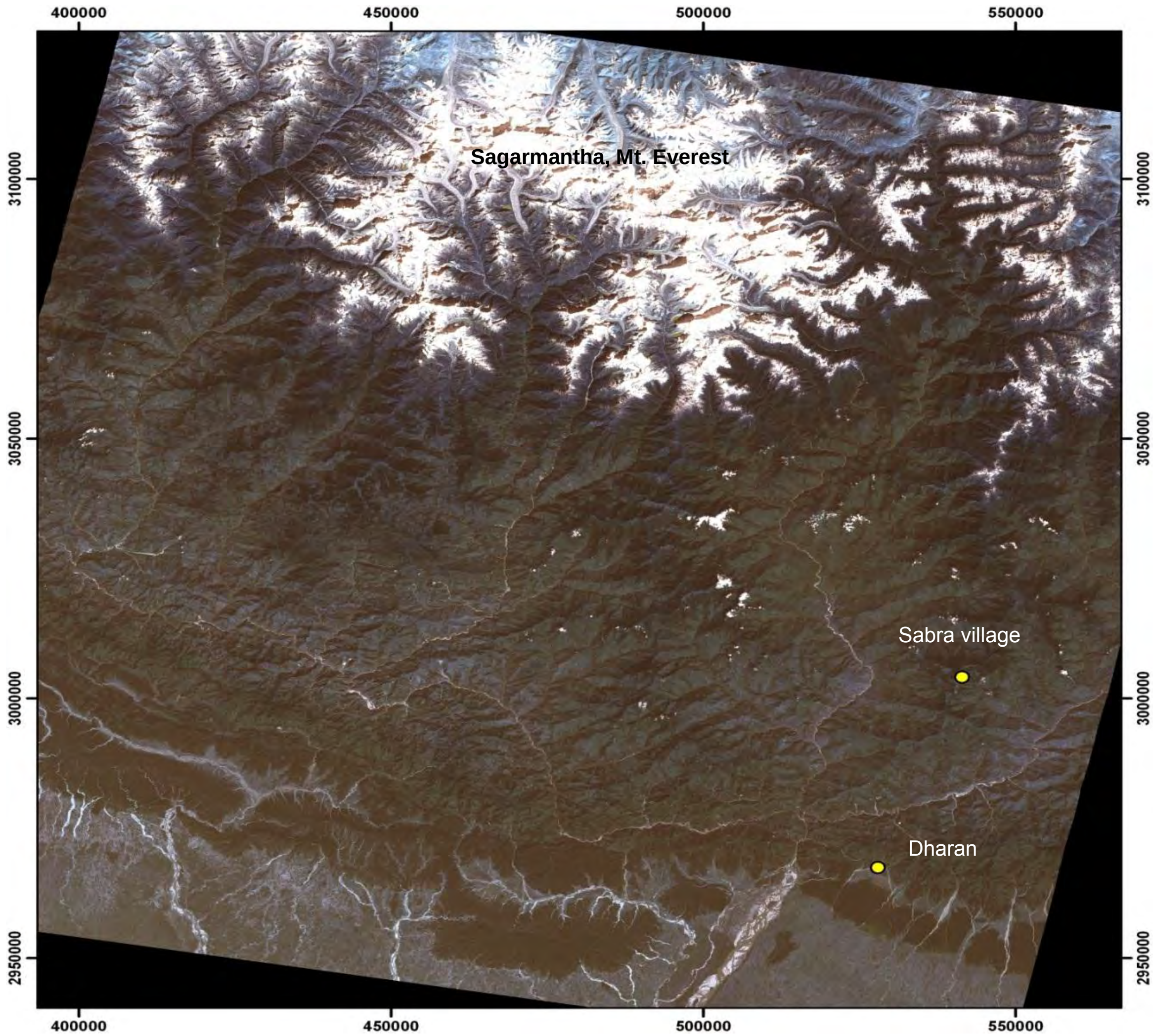


Figure 109. Landsat image of Koshi River Basin, Nepal, 2000/ ICIMOD-Nepal

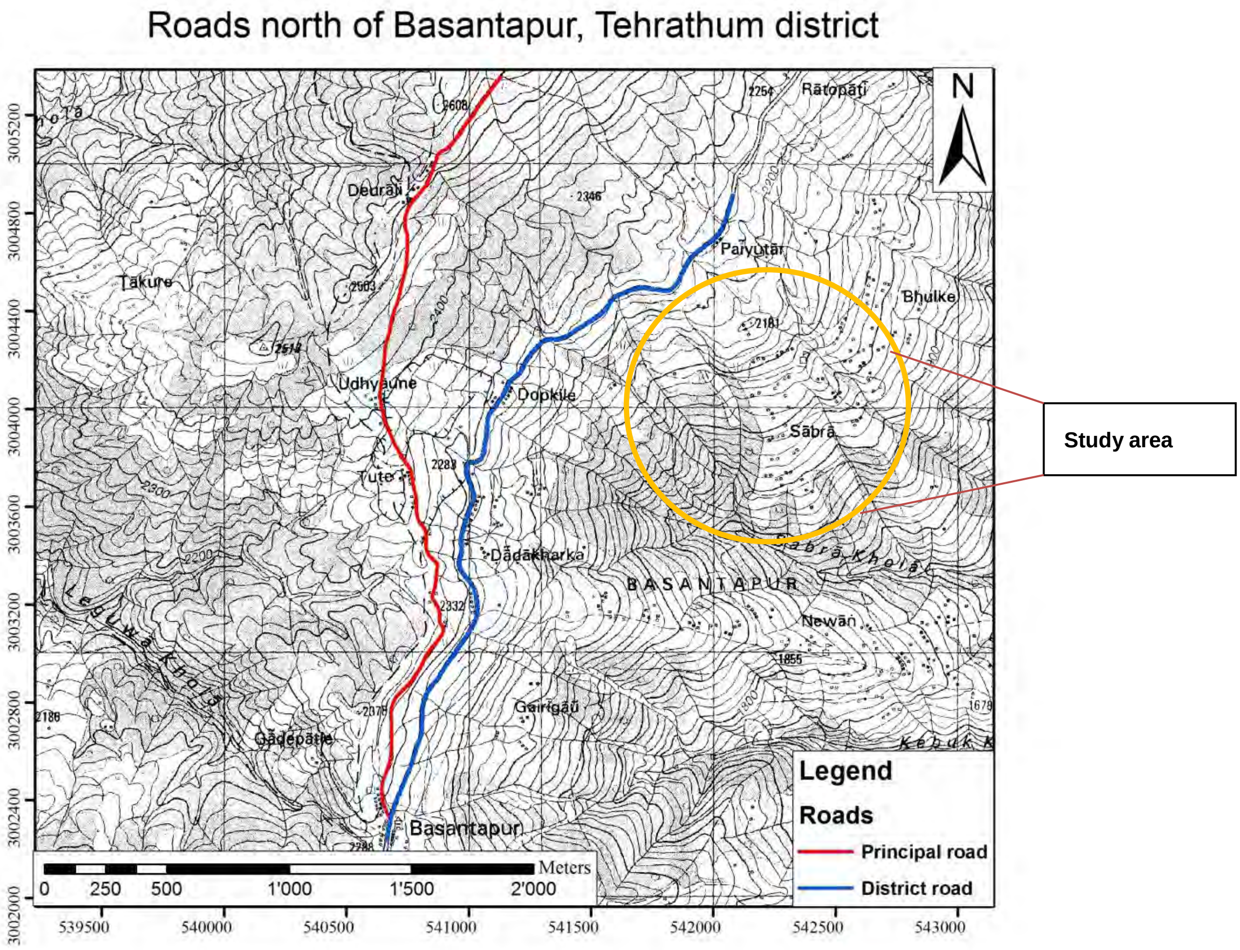


Figure 110. Map of Basantapur area, Tehrathum District (Dubois, 2009)

Figure 111. District road 800 m north of Basantapur. September, 2009.

Sabra environmental context (Figure 112)

- Average rainfall: 2000 mm;
- Sabra village is spread vertically between 1,800-2,200 m.a.s.l. starting from Sabra Khola river to the district road. Above the district road, another 300m vertical lies the community forest (Figure 113);
- The difference in vegetation between the bottom and the top part of the village allows for different micro climates. Rice is grown closest to the river, along with millet, colza, tea, cardamom, cabbage and cauliflower as one goes up the slope;
- Agriculture is a concern as production is decreasing according to respondents, perhaps due to superstitions about landsliding and decreased fertility;
- There are a number of naturally occurring grasslands and patches of deciduous trees and bamboo, often growing in gullies and river banks;
- The shift to cash crops occurred with the construction of the road, allowing easier transportation of cabbage. They are currently carried upslope to the road by neighbors and local labor in baskets weighing up to 40 kg. The special exposure of Sabra's slopes have given them a comparative advantage as they are often the first of the season to harvest cabbage;
- The CF *Chaite* was established 15 years ago, with a total area of 226 ha;
- The density of trees is becoming sparse due to a lack of oversight of caravans (horses and donkeys) coming from the high mountain areas to graze even if this is not permitted. There are eleven blocs in the forest and four of them are currently closed for grazing, due to the protection of rare Rhododendrons and to reduce degradation;
- All people living in Sabra are member of the CFUG. The main use of forest is firewood, collect fodder and grazing, however, many people in Sabra have their own forests for firewood;
- CF users have right to cut big trees only every two or three years per family;
- A tree nursery was established to improve the forest conditions.

Textbox 12.

Figure 112. Left: District road above Sabra village, 2009. Right: upper Sabra village, 2009.

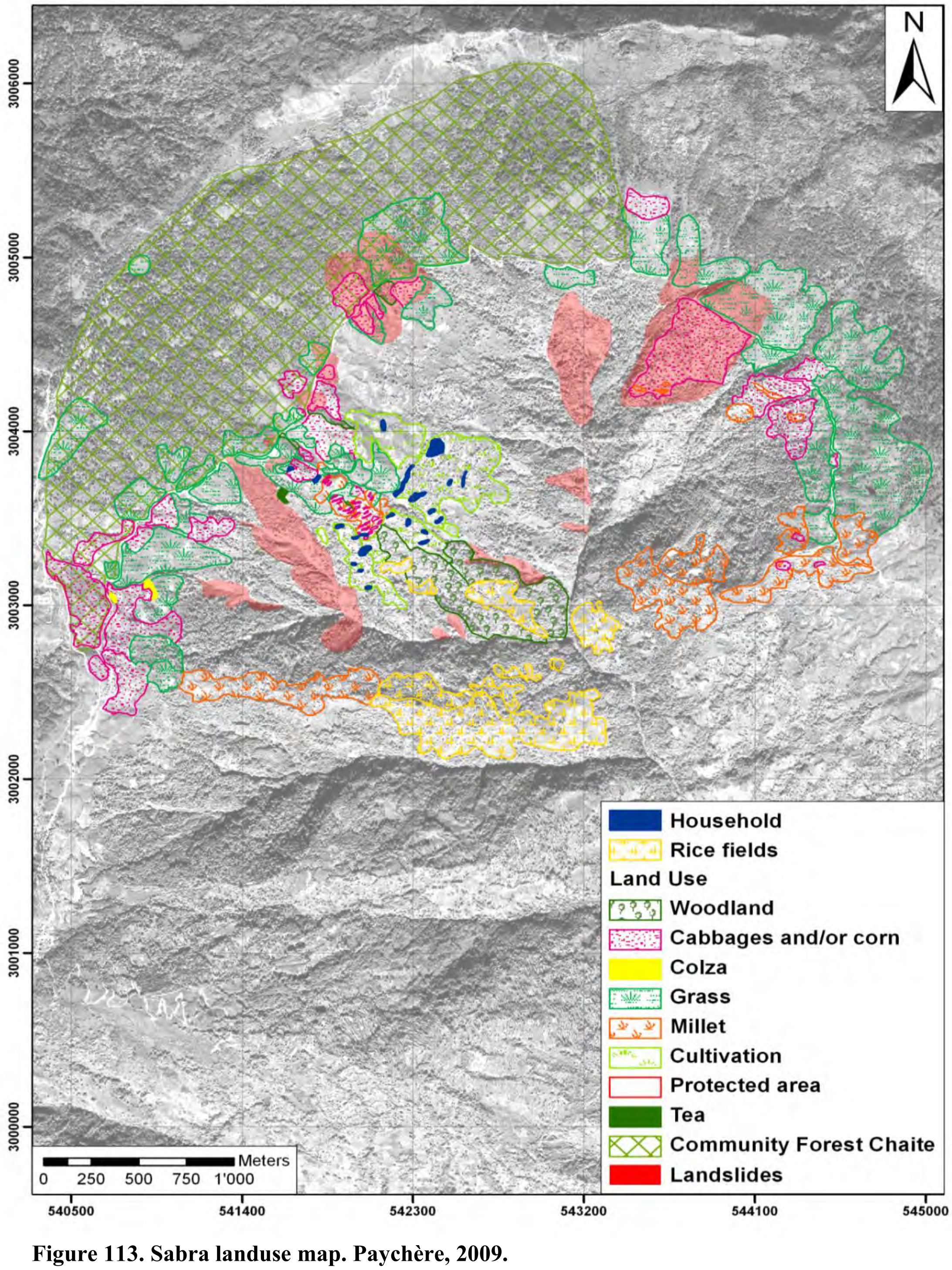


Figure 113. Sabra landuse map. Paychère, 2009.

One of the working hypotheses was that deforestation contributed to the landslide problem. We obtained aerial photographs of the Sabra area from 1992. Figure 114 shows that some forest area was lost and some was regained, with an overall slight decrease in forest cover by approximately 2%.

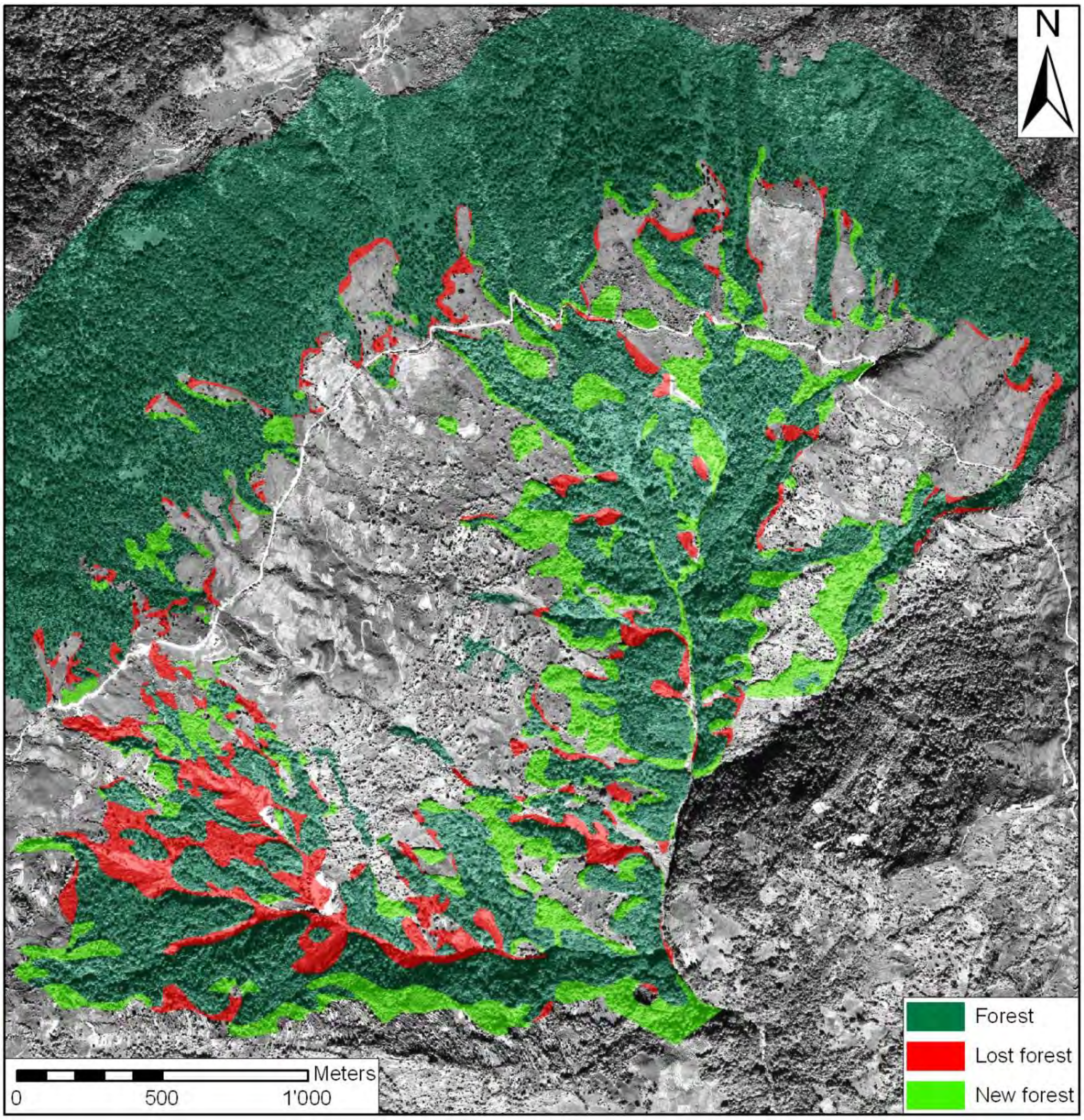


Figure 114. Forest map of Sabra's watershed. The forest area (dark green) is the forest existing in April 1992 when the aerial photo and the orthophotos were taken in November 2008. The lost forest area (red) was cut or destroyed between the two dates and the new forest area (light green) was grown in the same time (Dubois, 2009).

Sabra geological context

- The Sabra landslide affecting the main part of the village is complex in nature road side most likely due to improper road construction, lack of drainage of intensive monsoonal precipitation, forest clearing and conversion to agriculture terraces (Figure 115);
- As a result, local people report that the subsidence is more than 40 meters in the last 10 years and there is a shift of the road alignment every year;
- Ground water is excessive in the moving soil mass and toe portion of the hill is not sufficiently stable to retain the moving soil mass;
- Sabra is geologically located in the Himal Group, consisting of gneiss, quartzites and biotite schistes, muscovite and quartz (Figure 116);
- The rock is weathered and at times disturbed due to land sliding, with a large quantity of boulders at the soil surface, in gullies and streambeds. These boulders were probably transported by waterways and are thus not in their original location;
- The landslide area under investigation is covered by young trees *Uttis (Alnus nepalenisis*), typical of disturbed areas.

Textbox 13.

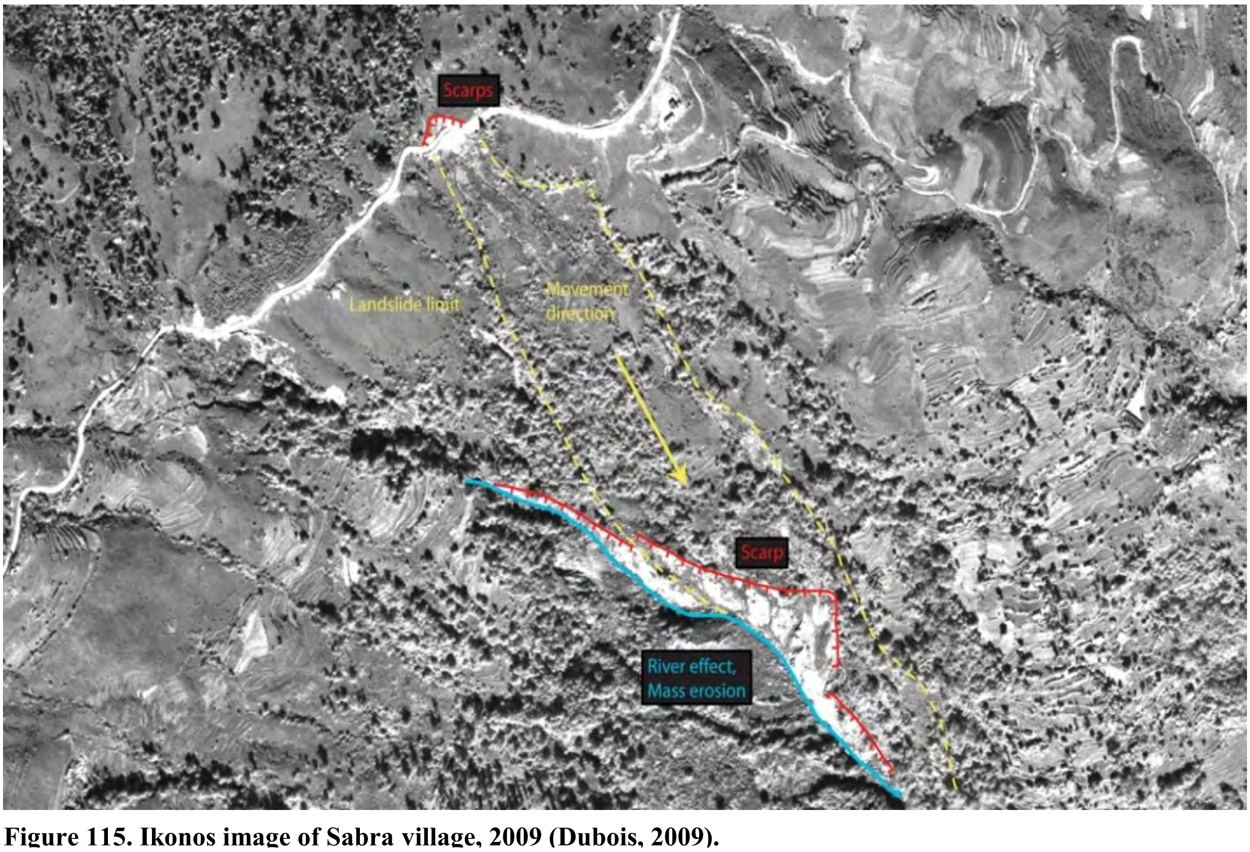


Figure 115. Ikonos image of Sabra village, 2009 (Dubois, 2009).

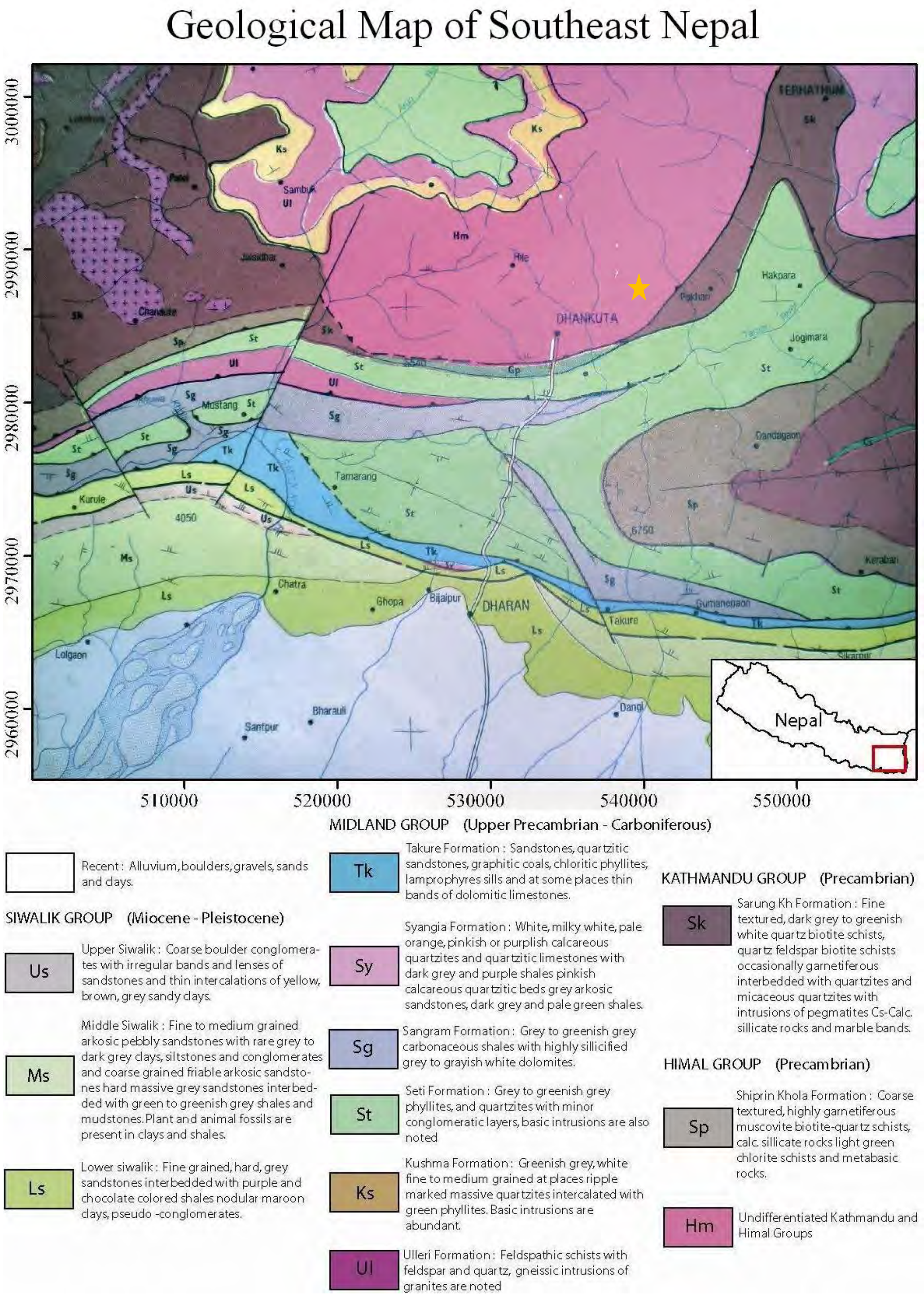


Figure 116. Geological map of Southeast Nepal. Dept of Mines and Geology, Govt of Nepal. 2009. Star indicates approximate location of Basantapur/Sabra.

Sabra social context (Figure 117)

- Similar to Khariswara, this is a high caste community (*chhetri*), which has been settled here for generations, with no recollections of previous origins;
- A relatively well- off village in terms of food security, landholdings, remittances and education. One resident has a fixed telephone line, the sole one of all surveyed;
- Houses are usually 2-storeys, with separate barns and outdoors pen for livestock;
- Four houses out of 22 in the village were destroyed by the landslide and many others are cracked.
- Some families have reported losing half their land to landslides, others all their land;
- All houses were rebuilt after the 1988 earthquake with government compensation and subsidies, using hired labor;
- Several families with sons abroad sending regular remittances;
- Primary school in village, secondary school 45 min walk in Basantapur. School teacher lives in village;
- Landholdings are spread out in different places due to inheritance. 90% of Sabra is in private land and 10% in government land, mainly at the top part of the slope;
- A small micro hydro turbine was installed to provide power to 14 houses in Sabra, thanks to a credit from the Asian Development Bank. However, now the village is connected to the electricity grid although supply is not reliable;
- Several families have biogas systems, cardamom drying installations, using firewood for quicker and higher quality drying and beehives for honey production;
- These innovations were brought to the village thanks in part to the higher access to external resources and several local NGOs operating in the area, among others, NORM based in Basantapur;
- Sabra has become dependent on the district road for bringing its crops to market. Road subsidence is cause for much concern;
- A very cohesive social structure as the village is active in collective projects, such as renovating trails and two cooperatives for pooling resources to provide micro-credits in support of business projects such as the purchase of livestock, or sewing machines;
- A well-organized Community Forest User Group (CFUG).

Causes of landslide

- Most mention the road construction and lack of drainage, a few mentioned superstitions causing the landsliding.

Coping strategies

- The main coping strategy is to monitor landslide activity and abandon houses as they become too dangerous but no special mitigation measures were undertaken;
- Some who lost their house moved to neighboring Basantapur but returns to the village to tend to his remaining land;
- Outmigration: several families have sent their sons to Gulf states and send home considerable remittances.

Risk perceptions

- Respondents are highly aware of landsliding and fearsome but with few alternatives in spite of their higher social status.

Priorities

- The main priority was to secure the road, mitigate the landslide, address unemployment and improve health care. No distinctions were made between men and women's priorities.

Textbox 14

"Most people here want to leave because it is too dangerous. We would like support to find other land."

Sabra resident, 2009

Figure 117. Top left: women carrying cabbage to market. Top right: farmer in front of his land affected by landslide. Middle right: Sabra village. Bottom right: Sabra Community forest (Paychère, 2009). Bottom left: landslide mitigation measures on road. Middle left: district road to Sabra, 2009.

5.4.2. Risk assessments

5.4.2.1 Geologist's risk map

The same "relative risk" method was used for Sabra as for Katahare; risk is thus the multiplication of this destruction potential by the vulnerability and the number of inhabitants (Table 36). However as opposed to Katahare, landslide risk was very obvious here. It was also very obvious that most of the land subsidence was caused by the road construction and this was also confirmed by accounts given by community members.

For Sabra, we observe high risk to (1 fatality within 50 years) for three houses and medium risk for 9 houses (1 fatality in next 100 years) in the central part of Sabra (Figure 118). This risk situation translates into a need for these inhabitants to monitor landslide movement during heavy rainfall and be ready to evacuate their homes in case of landslide movement. Red crosses indicate the four houses that have already been abandoned, and this decision was justified as these houses were cracked and dangerous for their inhabitants. White circles next to yellow markings indicate animal barns.

Id	Description	Vulnerability (V)	Loss (W)	Hazard (Pd)	Risk (R)
	House	1	5	3	15
	House	1	5	2	10
	House	1	5	2	10
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	3	15
	House	1	5	3	15
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	2	10
	House	1	5	2	10
	House	1	5	2	10
	House	1	5	2	10
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	House	1	5	1	5
	Barn	1	0	2	0
	Barn	1	0	2	0
	Barn	1	0	1	0
	Barn	1	0	1	0

Table 36. Relative risk calculation, Sabra village (Modified from Dubois and Breguet, 2009)

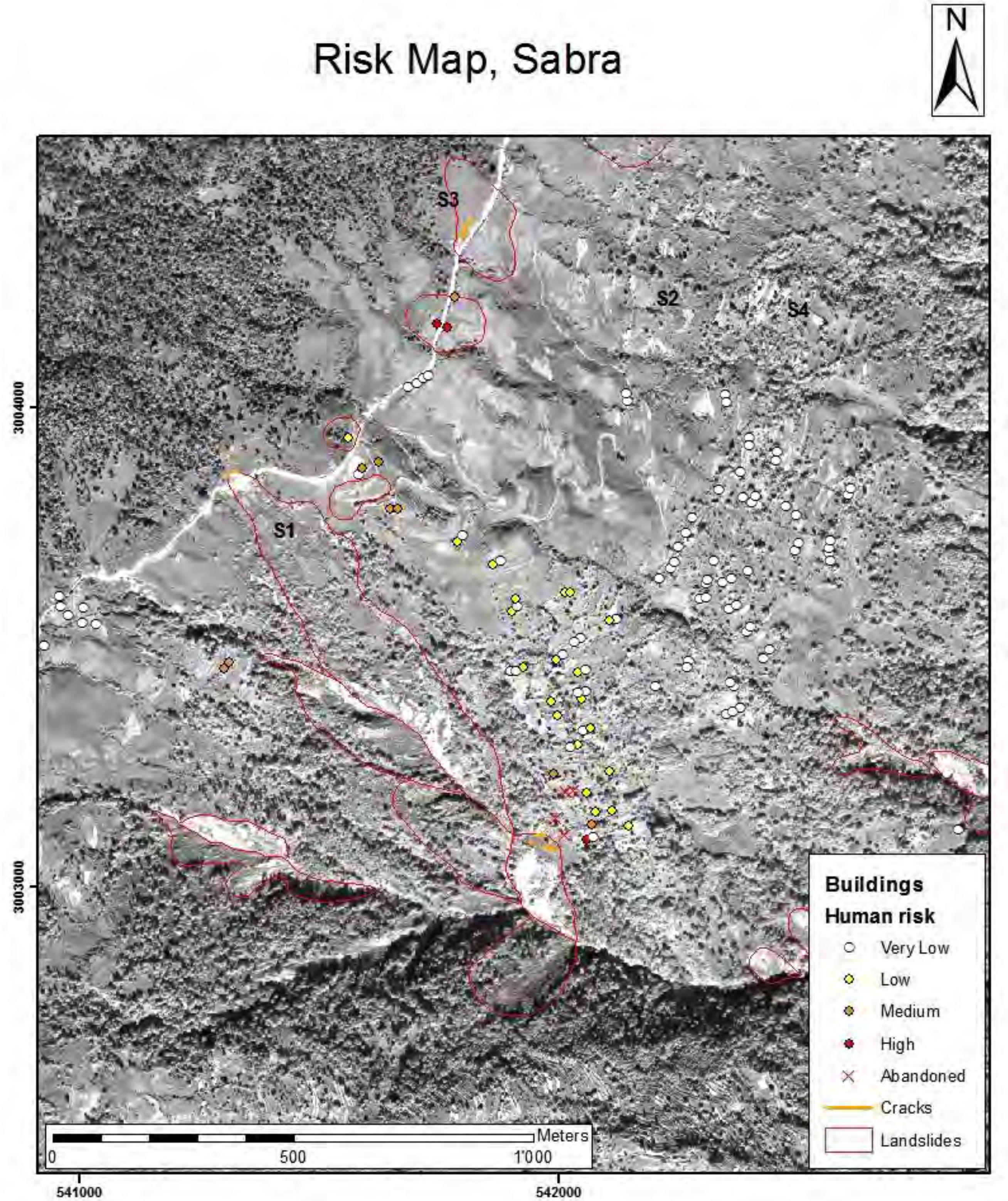


Figure 118. Geologists' risk map of Sabra. Houses marked in white next to yellow buildings are animal barns.

Class	Timeframe	No. of houses (casualties)
High	Within 50 years	3 (16.5)
Medium	50-100 years	9 (49.5)
Low	100-200 years	21 (115.5)
Very low	200 + years	-

Table 37. Number of houses and people at risk, Katahare

5.4.3. Synthesis and discussion

Roads obviously play an important role for the development of the region, for transportation to markets, employment, schools and also as evacuation corridors in the case of large rainfall or earthquake events. For Sabra the road changed its way of life, allowing for greater investments in cash crops, requiring transportation, creating more wealth but also more vulnerability as the road also changed the hydrological conditions of the watershed, destabilizing slopes. The local economy is now dependent on the road for transportation, which would make a road collapse especially disastrous. Several roadside mitigation measures were observed, gabion walls, geotextiles and piles, none particularly effective. As hydrology and toe cutting are the likely main causes of land sliding along and below the lower road from Basantapur to Sabra, we also recommend remedial actions, which mainly pertain to drainage trenches, reprofiling, or grading slopes to a gentler slope (approximately 30° for this lithology - using bulldozers); followed by stabilizing slopes using geotextiles, piles and re-vegetation using local plants with deep roots, such as bamboo. Below the road, the population should concentrate efforts on channelizing water away from cracks, and monitoring further slippage. Under heavy rainfall, houses in the danger zones should be evacuated. Above the road, possible interventions are slope grading, combined with geotextiles and supporting piles (Upreti & Dhital, 1996). There is also the possibility of a large-scale landslide triggered by a medium-sized earthquake for which emergency planning is required. Development strategies, and road construction for such high risk areas therefore, need to incorporate a hazard risk reduction component and vice versa.

Sabra was also the village where we spent the least amount of time, due to weather, road conditions and logistics. The main survey tool used were questionnaires and transect walks, sufficient for a general understanding of the village but not providing in-depth information, as participatory risk and social mapping.

5.5. Case study V. Dharan Municipality

Dharan Municipality Fact sheet	
Location	**Wards 4, 9.** 26°81’87’’N, 87°28’08’’E 1,800-2,200 m.a.s.l.
Average annual rainfall	1,800- 2,200 mm
Population size	Total Dharan, ca. 100,000 Sardu River neighborhood: population 650 Seuti Khola neighborhood: population 500 Khahare Khola neighborhood: population 300
Average household size	5.4 persons
Occupations	Day laborers, factory workers, shopkeepers.
Average loss due to flooding	30% frequent damage to property
Average age	29 years
In-migrated population (last 30 years)	76%
% families with one member abroad	16 %
% families receiving remittances	16%
Ethnic group	*Brahman* 21% (high status); *Tamang* 20% (indigenous “middle status”), *Rai* 16% (indigenous “middle status”), *Dalit* 14% (“lower status”); *Shrestha* 9% (high status); Other 20% (11 other ethnic groups)
Average land holding	- ha
Literate	61%
Average food supply	- months
Average % mobiles	25%
Electricity %	95%
Good sanitation facilities*	83%
Community priorities	Improve roads, employment and flood mitigation.

Table 38. Dharan Municipality Fact Sheet

Dharan Municipality	
Surveyed population and methods **September, 2008** **October, 2009**	n= 59 household surveys transect walks DF IGAR flood modelling (Dubois, 2010) Landslide assessment Google Earth satellite images, 2004 Geo Eye satellite image, 2009 Topographic sheets, 1:10,000

Table 39. Dharan methods table

5.5.1. Overview

Without developing full case studies, for comparison's sake, data are presented here on two flood-affected sites in Sunsari district: Punarbas, downstream from Katahare, a town with a population of 3,500; and several flood affected neighborhoods in Dharan, a city with a population of 100,000. Data for these sites were collected using the same questionnaire as for the landslide areas as part of the Master's thesis of Gopi Krishna Basyal, ITC, Netherlands. The following data presented are thus based on data collected primarily by Mr. Basyal, together with surveys completed by this researcher, in-depth interviews of affected populations in Dharan and Punarbas and two focus group discussions conducted by myself in Punarbas. In parallel, our team's geologists conducted an in-depth risk assessment of Dharan's landslides and flood situation (Breguet et Dubois, 2009; Dubois, 2010). These two areas were selected for the risk posed by flooding and ease of access.

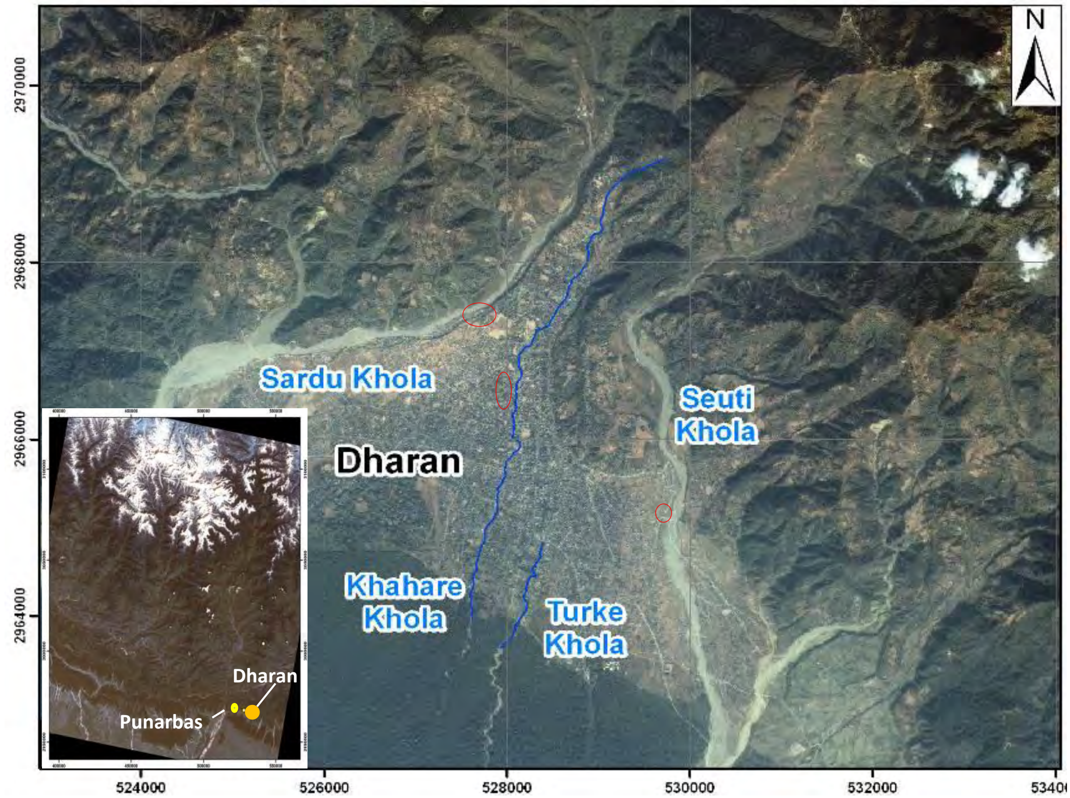


Figure 119. Dharan situation map, Geoeye satellite image, 2009: inserted left, Landsat map of Eastern Nepal, courtesy of ICIMOD.

5.5.2. Dharan Municipality[4]

Dharan is situated on a large alluvial fan in the upper part of the *terai* region, below the Siwalik foothills, with an average elevation of 400-500 m.a.s.l. The region is characterized by a tropical climate and intensive monsoon rainfall period between June-September with average rainfall in Sunsari district 2,600 mm per year (Dharan Muncipality, 2011). The maximum rainfall is about 460 mm which usually occurs in August. Two major rivers running north to south, define Dharan's limits: Sardu to the west and Seuti to the east. Two other rivers also cross the city, which are temporary in character and high flow of water when it rains. Flash flooding is very common in these two *Khahare* (temporary) rivers or more permanent *Khola* rivers. Similarly there are number of active landslides within the catchment. Low lands adjacent to these rivers/streams in the area are likely to be affected by floods as they are prone to flood hazards.

The city was severely damaged by the 1988 earthquake (6.8 in Richter scale), which killed 138 people, injured 2,117 people and damaged 2,500 buildings (NSET, 2011). Yet, flooding is the most common hazard to settlements along the major rivers Sardu Khola and Seuti Khola, many which live directly in the flood plain, on terraces in the river bed. This encroachment has especially occurred over the past 5 years by landless people emigrating here for access to employment and education. The most exposed households have to rebuild their houses almost once a year because of flooding. Smaller tributaries, which cross the city, Khahare Khola and Turke Khola are also subject to inundations and flash flooding. An September, 2009, a school collapsed because of flooding along Khahare Khola. In addition to floods, slope failures causing landslides are common on the western bank above Sardu Khola and in the upper catchment of Seuti Khola. In the event of a middle to high intensity earthquake, there is the possibility of a large landslide blocking Sardu Khola and creating an artificial dam, putting the river's communities in great danger. River bank erosion also poses a threat to houses along the left bank of Sardu Khola.

Figure 120. Characteristic house of retired British army recruit, 2009

According to the Dharan Municipality (2011), the city has evolved as one of the major trading cites between the mountain area and India. It has prospered thanks to the British `Gurkha Recruitment Center' in 1953, which helped many Nepalese gain employment and settle here to retire with generous pensions from the British army (Figure 120). The dominant ethnic groups are mainly *Rai* and *Limbu*.

[4] This section was published in Sudmeier-Rieux et al., 2011(In press (b)).

Dharan

Environmental context

- Tropical climate, with max temp. of 32°C and min. temp. 10° C;
- Annual rainfall: 2,600 m;
- Located in alluvial fan (Dharan formation) below Siwalik foothills (Lower Siwalik formation and Middle Siwalik; formation) at 400-500 m.a.s.l. (Figure 121);
- Population was estimated at 100,000 in 2009 (Dharan Municipality, 2011);
- The city is considered one of the best planned and progressive cities of Nepal;
- It is flanked by two rivers: Sardu in west and Seuti in the east, with several smaller rivers crossing the city, Khahare Khola and Turke Khola, all subject to inundations and flash flooding;
- Dharan was severely damaged by the 1988 earthquake (6.8 in Richter scale) but flooding remains the greatest hazard;
- Two major rivers define Dharan`s borders, Sardu to the west and Seuti to the east. Two other rivers cross the city, subject to flash flooding. Communities along the Sardu River are affected by riverbank erosion;
- Land slides are a problem on slopes along the West side of Dharan, mainly affecting terraces along the slopes as people are no allowed to live here. A large earthquake and heavy rainfall could trigger a major landslide, creating an artificial dam, seriously threatening the population living along Sardu River (Figure 122, Figure 123, Figure 124, Figure 125);
- Housing conditions for these communities are very poor. Most live in one story makeshift huts constructed out of bamboo, iron sheets, or other light materials. There is a big difference between the poor landless communities, many living along the rivers and wealthy retired British army recruits living in immaculate three-story houses sometimes only 1 km away from poor River communities;
- There are nine community forests around Dharan, with various levels of management and forest degradation
  (Figure 126);
- Before the community forests were established, the hill sides were very degraded, according to survey respondents; Now there are strict rules for gathering fodder and degradation has been reduced.

Social context

- Mostly migrants from the Koshi area and elsewhere, most migrated here, drawn by better economic opportunities but also due to landslides and flooding in the Middle Hills, representing a number of ethnic groups and castes: *Dalit, Rai, Tamang, Gurung, Karki, Shrestha, Brahmin.*
- Most people living in the Sardu River community are stone collectors, gathering stones from Sardu River and breaking them into gravel manually. The community living by Khahare Khola and Seuti Khola are very poor day laborers, having migrated here from other places in the Middle Hills or Koshi River. They are not involved in any agricultural activities;

Causes of flooding

- Heavy rainfall was named as the first cause of flooding, followed by urban runoff and river canalization.

Coping strategies

- Most River community households do not have any coping strategies other than rebuilding, cleaning and trying to keep any valuable household items dry during frequent flooding;
- Some gabion walls have been built to protect River communities from flooding but these are not entirely effective, as all respondents claimed that they were flooded several times every year.

Risk perceptions

All respondents were very worried about the flash flooding and considered the probability of repeated flooding very high.

Priorities

- Main priorities were development related: mainly education, employment, road development, followed by flood mitigation.

Textbox 15

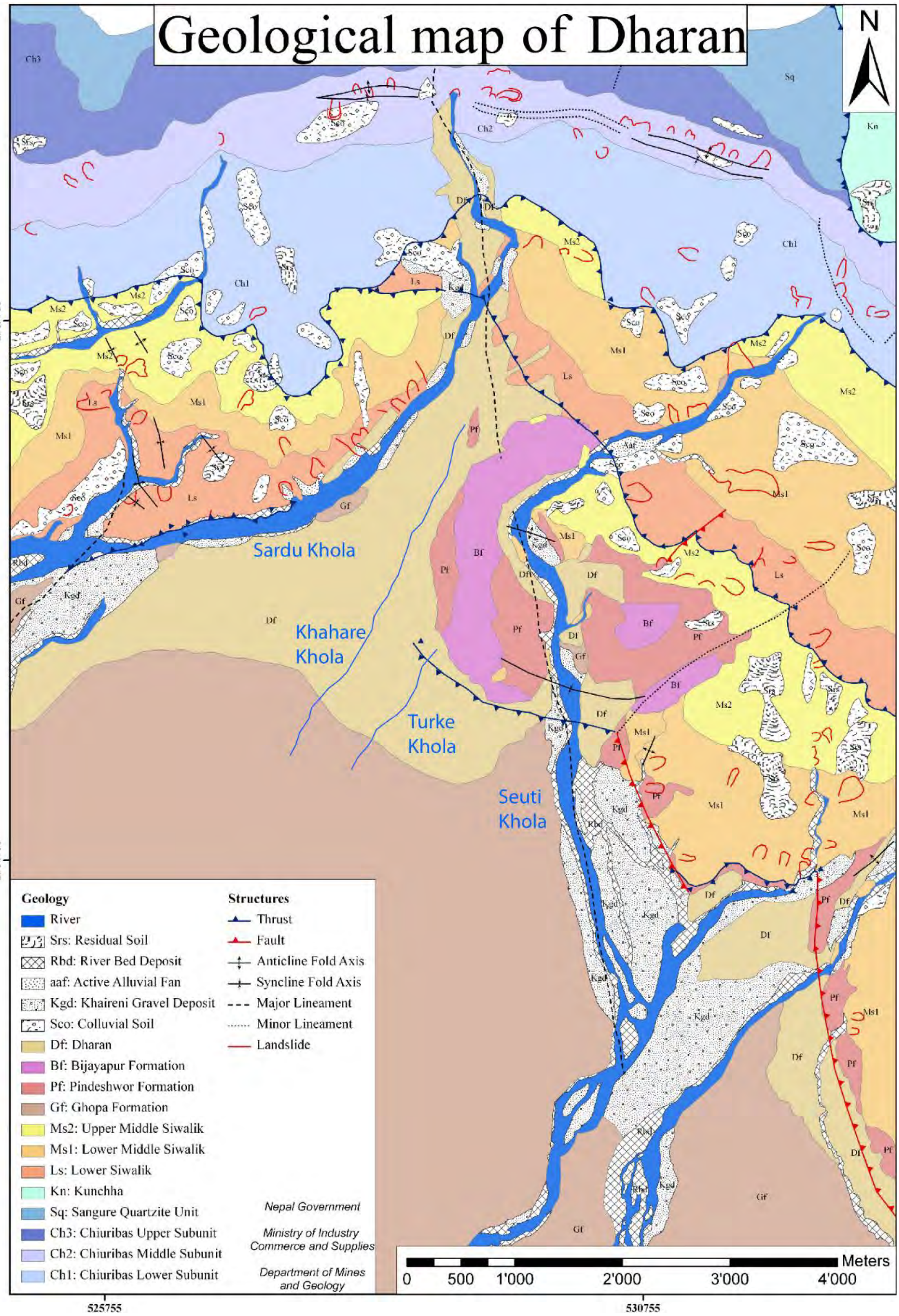


Figure 121. Geological map of Dharan. (Nepal Department of Mines and Geology, 2007)

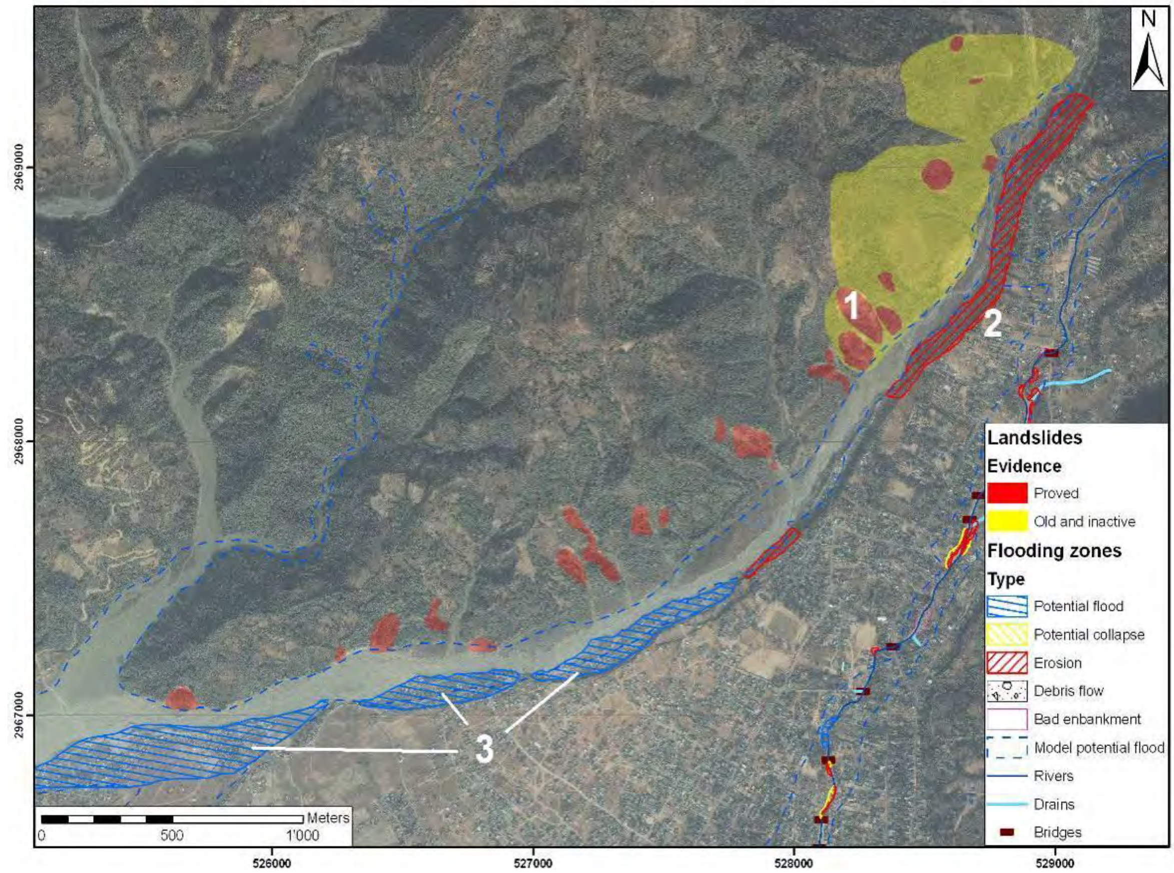


Figure 122. Landslide areas by Sardu River; 2. Erosion prone areas; 3. Flood affected areas. (Dubois, 2010).

Figure 123. Left: Sardu River and right bank. Right: Sardu River right bank landslides.

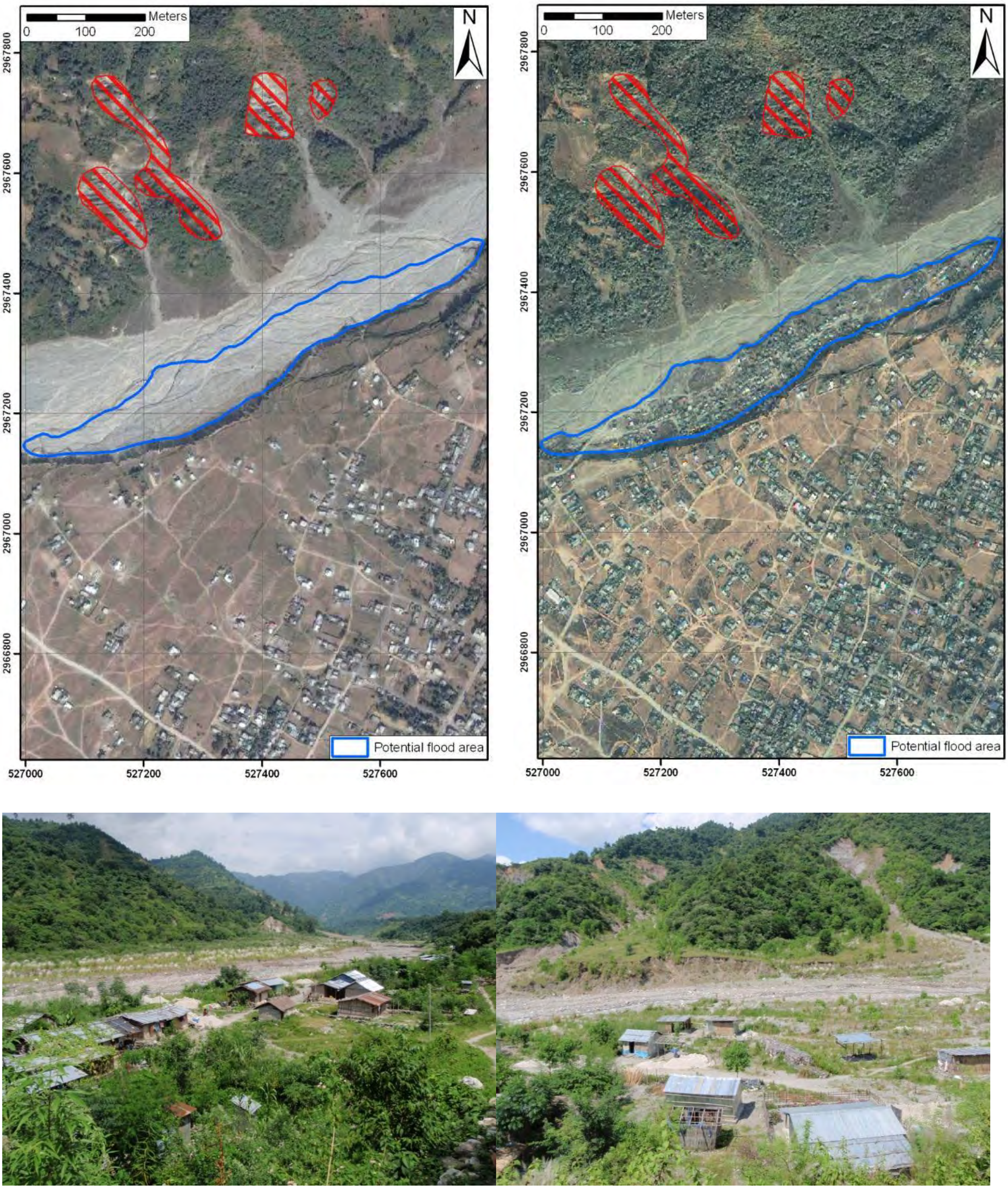


Figure 124. Top left: Google Earth image from the 2004 of the Sardu River. Top right: Same riverbank in 2009, (GeoEye, 2009) with new unplanned settlement in the riverbed (Dubois, 2010). Bottom left and right: Sardu River community living in river bank.

Figure 125. Top left: Google Earth image, 2004 of Seuti River. Top right: Same river bank in 2009 (GeoEye, 2009) with new unplanned settlement in the riverbed. Bottom left: House with three family members living by Seuti Khola; Bottom right: gabion wall along Seuti Khola, September, 2009.

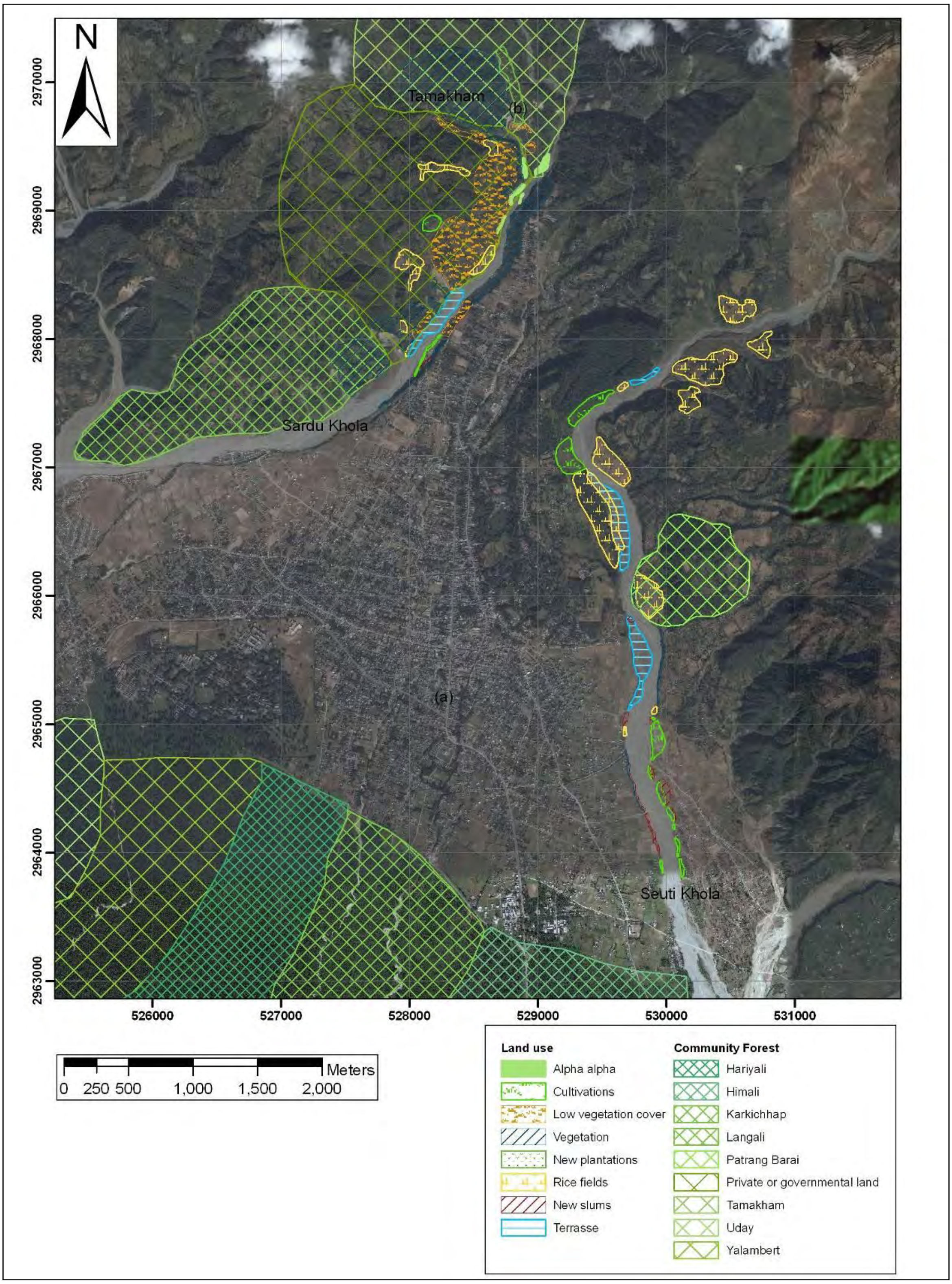


Figure 126. Dharan's community forests and land use (Paychère, 2009).

5.5.3. Flood risk model (FLOW-R)

The **FLOW-R** flood risk model was developed based on digital elevation model (DEM) calculated from 20 m contour lines of the topographic map field studies and satellite images: a Google map from November 2004, and Orthophoto Geo Eye pan-sharpened image, from December 2009, was purchased for this study and available rainfall data from the Nepal Ministry of hydrology for Dharan. The modeling was developed using the software **FLOW-R** (Horton et al., 2008). Originally it was designed to model debris flows, but it can also be used to model floods (Jaboyedoff et al., 2010). It detects potential hazard sources and calculates the fluid propagation of debris flows, floods or avalanches. Here, the detection of the sources was conducted manually by adding the potential overflow identified during the field study to the river bed. The model uses two algorithms to calculate the propagation from the given sources on a Digital Elevation Model (DEM), which is a grid showing elevation changes. The first one calculates the flow direction probability dependent on the slope. The second one defines the length of propagation using the potential energy (Dubois, 2010). The main outcome of the model is a susceptibility map (Figure 127), which illustrates potential flooding indicated for a 10-year return rainfall event, in the range of 250-300 mm. With reliable climate change predictions at a local scale, it would be possible to produce several scenarios of flooding that can be useful for local flood planning, as well as developing risk maps. Such maps take into consideration population vulnerability and exposure as well. Results from our study and modeling were used to prepare a study of the Sardu River watershed to improve management of the water supply for the city (IUCN-Nepal, 2011). However, according to Suraj Shrestha, head engineer at the Dharan Municipality (personal communication), none of our research findings have been implemented to reduce flood risk due to lack of capacity at the Municipality. Main problems are: 1/ structural, the need to physically reduce runoff and improve urban infrastructure; 2/ increased number of people living by hazardous areas, the need to physically relocate River communities; and 3/ capacity of the municipality to undertake the above actions.

This situation highlights a very common problem in Nepal: Municipalities and local government are overwhelmed with basic every day issues of water supply, sanitation, basic maintenance, without being able to properly address any other issues, such as flooding, landslides, earthquakes or other physical safety issues. Low budgets, low salaries, a brain drain of educated professionals are hampering local development. Thus for climate change, which is still considered a problem of the future, the problem is not access to information about flooding, but rather lack of capacity and budgets to address most urgent municipal needs of today.

Figure 127. Top picture: Debris Flow-R Model (Horton et al. 2008) was used to model water propagation in the case of overflow of Dharan's watercourses. (Dubois, 2010); Bottom left picture shows sedimentation after September 2009 flash flood of Khare Khola River River (Dubois, 2009); Bottom right picture shows destroyed school after same event (Dubois, 2009).

5.6. Case study VI Punarbas Township

Punarbas Township Fact sheet	
Village location	**Barahachhetra VDC, Ward 3** 27°10´57"N, 87°27´47" 100 m.a.s.l.
Average annual rainfall	1,800-2,200 mm
Surveyed population	n= 42, 2 focus group discussions and transect walks
Population size	Total, 10,000. Ward 3, Pop. 400
Average household size	5.3 persons
Occupations	Day laborers, salaried government employees, farmers, teachers.
Average loss due to flooding	26% experienced some damage to their house 8% experienced damage to land
Average age	29 years
% families with one member abroad	27 %
% families receiving remittances	27%
Ethnic group	*Brahman* 50%(high status); *Dalit* 16% (lower status);*Rai* 16% (indigenous middle status); *Newar* 14%(indigenous middle/high status); *Sherpa* 4% (indigenous middle status).
Average land holding	0.23 ha
Literate	40%
Average food supply	3.3 months
Average % mobiles	70%
Electricity %	89%
Good sanitation facilities*	76%
Community priorities	Improve roads, employment and flood mitigation.

Table 40. Punarbas Township Fact sheet

Punarbas Township	
Surveyed population and methods	n= 42 household surveys 2 focus group discussions and transect walks Google Earth satellite images, 2004 Topographic sheets, 1:10,000

Table 41. Punarbas Township methods

5.6.1. Overview

Punarbas township (population of 10,000) is located 8 km downstream (south) of Katahare, 3 km east of Koshi River and 15 km west of Dharan (Figure 128). It was established 40 years ago, when 400 households were relocated here from the Koshi area after the dike was built with assistance from the Indian government. It was planned by the Royal administrator, with houses built along grids in neighborhoods. As elsewhere in Nepal, unemployment is a problem in Punarbas, although it may be underreported at 16% by our estimates, as many respondents also have some farming activities. Most commonly mentioned employment, is agriculture, day labor (stone collection) and skilled employees: teachers, policemen, soldiers. Some houses even have stockpiles of stones in their front yards, awaiting purchase. After the 2008 Koshi dyke rupture, demand is quite high for Bagh River stones.

As reported by local people, the area experienced frequent minor flood/inundation during monsoon season every year (Figure 128). The reason behind the inundation is due to flood in the *Bagh Khola* (Khola - Small River), which is flowing distributive and has no embankment throughout the river course. Massive sediments and debris that has been generated in the *Bagh Khola* originating in Siwalik brings the sediments from the upper reaches and deposits while it reaches in the plain as the velocity get reduced in the plain area.

The river morphology has been changing due to un-planned excavation and collection of river material such as gravel and boulders. The local government has built gabion embankments on right side of the *Bagh Khola* without considering the river morphology and sediments load in the river that has forced the river to change its original course and spread all over the plain area where there is no dyke or river embankment is main cause of flood in the Punarbas area. Furthermore, the road network built inside the Punarbas community has no or insufficient cross drainage structures that consequently increase to inundate the settlement.

The community is situated in between two rivers which used to overflow on a yearly basis before dykes were built. Now the main concern are flash floods. Only four hours of rainfall in the hills are required before the river overflows, “sometimes it does not even rain here but in the hills and the flood reaches here anyway.” There usually are no casualties but some 50 households in the lower part of the community can still be flooded regularly, including the secondary school. People blame the flooding on the stone collectors who have changed the course of the river and deforestation by villages upstream. However many people live off the stone collection, and the local government, DDC earns good income from this activity (250,000 Rupees/year). 30% of this revenue is supposed to be spent on development activities in the affected communities but residents claim this is not the case and the DDC would be better off regulating this activity to reduce flooding.

Figure 128. Focus group discussion in Punarbas, 2009.

Punarbas Township (Figure 129)

Environmental context

- Punarbas is located 8 km downstream (south) of Katahare by the Bagh river in the upper Terai region;
- Established 40 years ago, when 400 households were relocated here from the Koshi area after the dike was built with assistance from the Indian government;
- A planned town, (pop. 10,000) with houses built along grid lines;
- Houses vary between two-story wooden houses, with valuable items usually kept on top floor to one-story bamboo huts, not well adapted to flooding;
- Located between two rivers which used to overflow on a yearly basis before dykes were built.
- Main concern are flash floods which threaten 50 houses and the secondary school with 400 students.
- There are several community forests here and a well-established CFUG;.
- According to respondents, due to the vastness of the area and lack of forest guards, poaching is a concern and the forest is quite degraded.

Social context

- Mostly migrants from the Koshi area and elsewhere, most migrated here, drawn by better economic opportunities but also due to landslides and flooding in the Middle Hills;
- Relatively well-off "middle-class" community. Most people in this community have some type of employment, such as teachers, policemen, soldiers, combined with agriculture and stone collection
- Several ethnic groups combined: *Brahmin, Newar, "Hill-Chhetri", Rai, Dalits;*

Causes of flooding

- Deforestation was named as the first cause of flooding, ahead of stone collection.

Coping strategies

- Most valuable household items are kept on top floor, or can be moved upstairs if needed;
- Some drenches were dug to divert water in addition to the gabion walls and dykes erected upstream to divert Bagh river.

Risk perceptions

- All respondents were very worried about the flash flooding and considered the probability of repeated flooding very high.

Priorities

- Main priorities were development related: mainly education, employment, road development, followed by flood mitigation.

Textbox 16

Figure 129. Top left: gabion walls along Bagh River; top right: Punarbas town; middle right: Punarbas house; bottom right: flood drench; bottom left: focus group discussion; middle left: flooding after heavy rain. October 2009.

5.6.3. Migration patterns of residents in Punarbas and Dharan

As migration is a key factor explaining rural development trends, this section was developed to compare migration patterns of residents in Punarbas and Dharan. Figure 130 illustrates a map of place of origin of migrants to Punarbas, with the greatest number of persons having migrated from the Bhojpur region and from nearby communities by the Koshi River. As 70% of respondents in Punarbas say they have migrated from elsewhere in the past 30 years, this phenonmena is quite significant for the town.

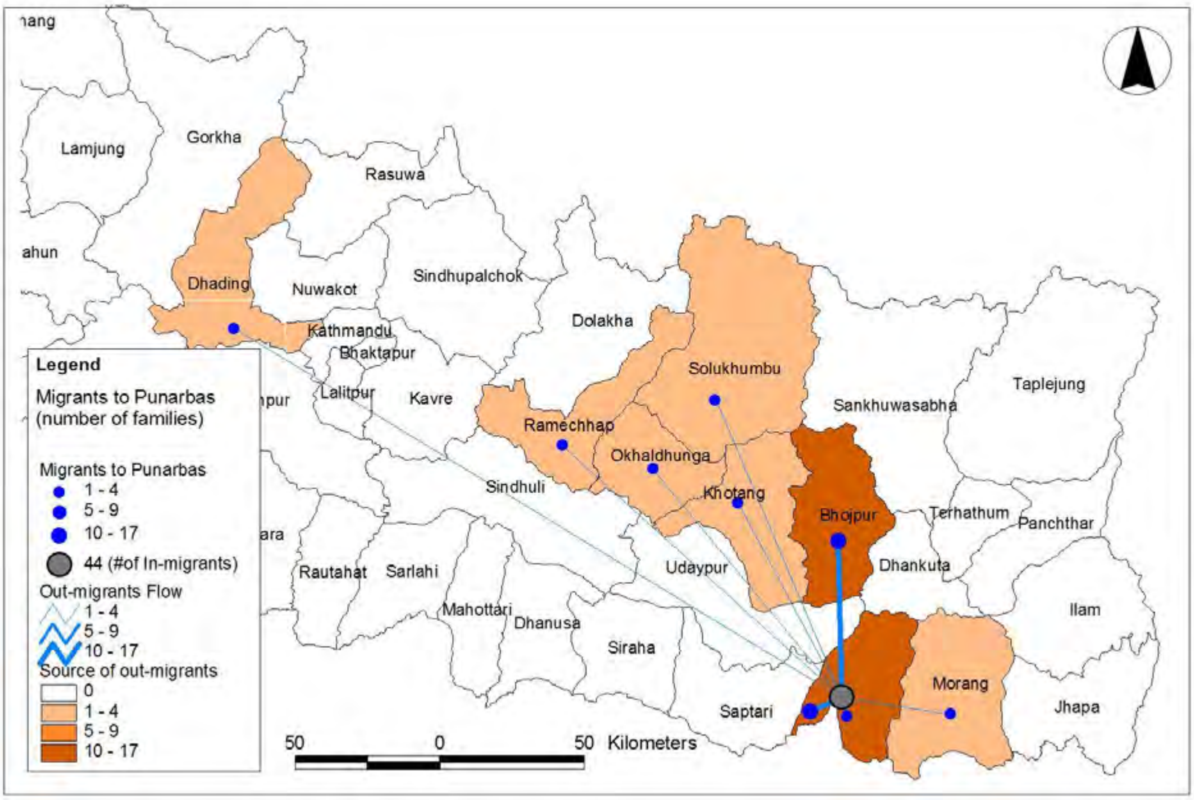


Figure 130. Map of migration patterns for respondents having migrated to Punarbas (n=44). (Map by Basyal, 2011).

Figure 131 illustrates migration patterns to Dharan according to responses from the household survey, where 76% of all respondents have migrated from elsewhere. The highest number of in-migrants come from neighboring areas south of Dharan as well as from the Koshi River area; second are migrants from Bhojpur and Dhankuta Districts. We note that the migration patterns are quite similar for the two destination places.

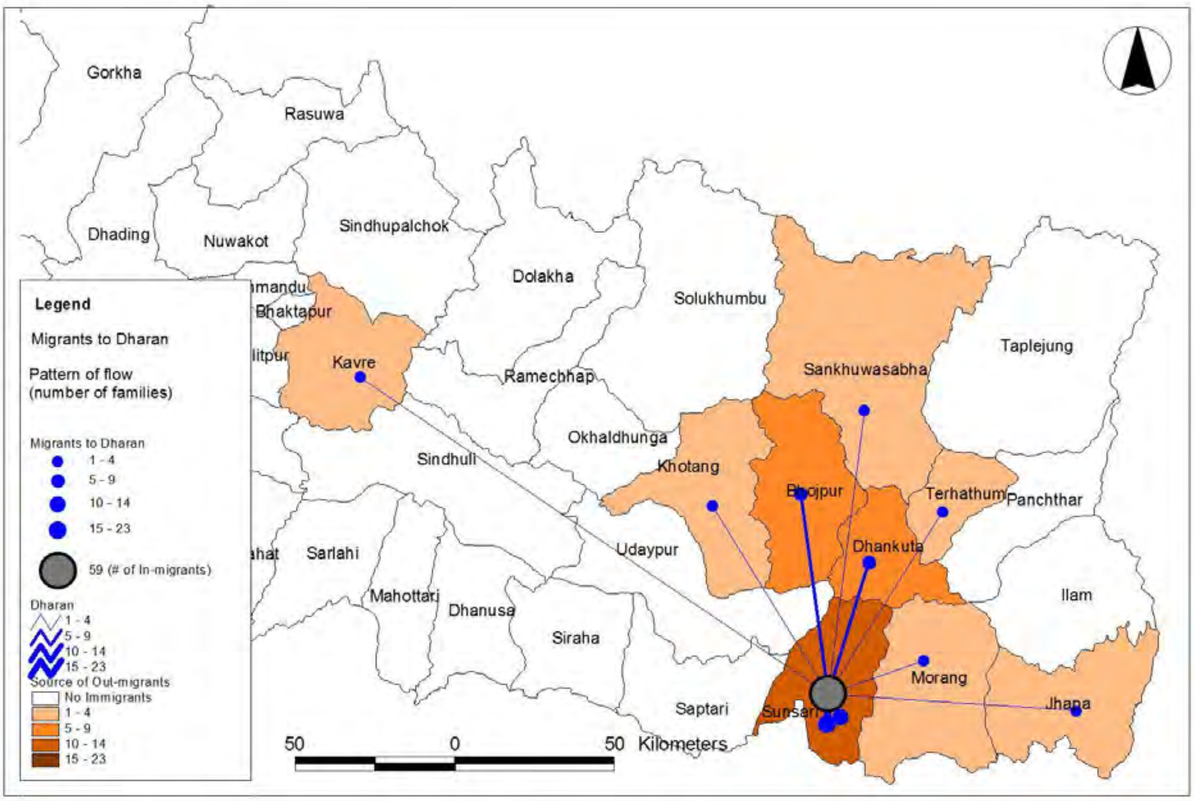


Figure 131. Map of migration patterns for respondents having migrated to Dharan (n=59). (Map by Basyal, 2011).

Figure 132 shows data on the various reasons for migration, with economic reasons being the prime cause (71% for Dharan, 51% for Punarbas), followed by disasters (20% for Dharan, 39% for Punarbas) and last family reasons, primarily women moving to live with their husband's family (10% for both places). These data are also consistent with other studies on migration, showing the high number of persons moving from the Middle Hills to the Terai mainly for access to better economic opportunities (Kollmair et al., 2009).

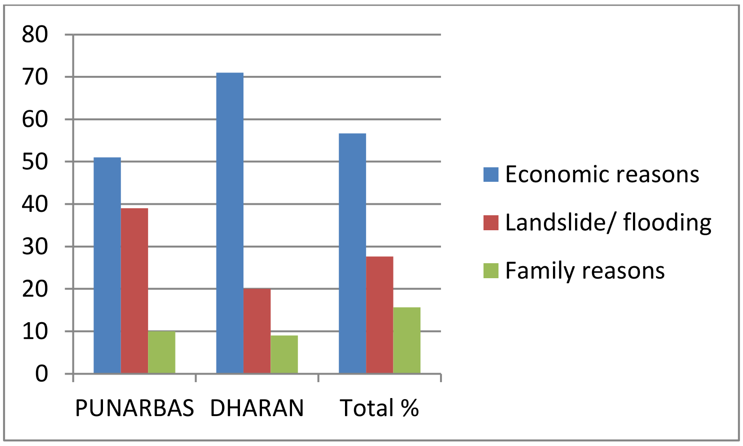


Figure 132. Reasons for migrating to Punarbas and Dharan.

5.6.3. Synthesis and discussion

These brief case studies of flood affected communities, Dharan and Punarbas were intended to provide a basis for comparison with landslide affected communities. Sampled communities in Dharan and Punarbas communities were the most affected. The two places are only 15 km apart but quite different from each other in demographic composition, origin, level of economic well-being, and perceived causes of flooding. In Punarbas, the surveyed population was better off in terms of economic well-being, education level and type of employment. Both areas are composed of in-migrated populations from the Middle Hills and the Koshi River. River communities in Dharan are marginalized populations having migrated to this area due to hardship elsewhere, either for economic reasons or due to disasters elsewhere. This fact is consistent with migration trends of populations moving from the Middle Hills to the Terai and urban areas since the 1960s with the eradication of malaria in the plains.

The flood affected communities differ from the landslide affected communities by much greater access to employment, roads, hospitals, schools, electricity, stores. Another interesting difference is that mitigation for flooding was undertaken by government agencies not the communities, in contrast to landslide affected communities, who are obliged to take responsibility for their own mitigation of landslides due to lack of resources for such activities in rural areas. Therefore, we also note the greater presence of government in Nepali towns and cities compared to rural areas.

Similarities between flood and landslide affected communities include a great prioritization on improving access to roads when they do not exist, or improving road conditions when they do exist. In both places, priorities also included development related issues such as, employment, health, education, almost always placed before landslide or flood mitigation. And this was the case whether the community was rich or poor. Another similarity is the amount of resources and time spent by households to either reconstruct houses, clean them, move them to another location due to flooding or landsliding. This is often in addition to lost assets, houses, sheds, productive terraces, irrigation canals, forest land due to landslides. Losses from flooding in contrast are usually more temporary than from landsliding.
We normally consider that it is mainly marginalized communities who live in dangerous places for lack of safer places to live. But for the landslide affected communities we studied, both rich and poor were affected by high risk due to landslides. For the better off communities, Sabra and Khariswara, both predominantly *Chhetri* and higher status, the coping strategy was to send many of their sons abroad. We found that better off communities send a higher proportion of their young men abroad as they can afford it. These men from higher castes are usually better educated and find better paying jobs abroad, allowing them to send home more generous remittances. Even if households can then afford to move elsewhere, away from landslide affected places, they tend to stay there until their houses are no longer inhabitable rather than move away. Hence, there are also social considerations, affective links with place, relatives and neighbors that keep people in dangerous places.

Results: comparative data

6.1 Descriptive statistics

6.1.1. Demographic and economic data

Differences between urban flood affected and rural landslide affected areas are not surprisingly marked by different levels of sectorial activity: the rural areas are dominated by agriculture and semi-skilled labor, with a high number of retired persons and wage earners in Khariswara, Punarbas and Dharan, whom most are unemployed (Table 42). The occurrence of priests and teachers in Khariswara is consistent with this high caste group's social role. Rural respondents did not report unemployment if they were engaged in some type of agricultural activity, even if they were also seeking supplementary employment, somewhat skewing this figure. The areas with the highest number of government employees are Sabra, Punarbas and Khariswara and are also primarily constituted by high caste groups with higher literacy rates, higher landholdings per household, more livestock per household, receiving more remittances, owning more mobile telephones, electricity and with more months of food stocks. This is consistent with other studies showing the high correlation between ethnic status and economic well-being (Bosher et al., 2007). Monthly expenditures for the urban respondents are not surprisingly higher, as households are more dependent on purchasing food, mirrored by the few respondents in Dharan with landholdings and livestock. Sabra has relatively high numbers of livestock due to the terrain, which is largely grasslands, in addition to the good economic situation of this village.

As described above, in- migration has played an important role for several communities, especially Katahare, Punarbas and Dharan, communities situated in the Terai plains or foothills, confirming the continuing trend of out-migration from the Middle Hills (CBS, 2009a). Reasons for the migration are mainly economic, followed by landslides or flooding elsewhere, which caused respondents to relocate.

Demographics and economics	Sabra	Thang/ thang	Khariswara	Katahare	Punarbas	Dharan	Average
	n=11	n=13	n=13	n=30	n=42	n=59	n=168
Agriculture	80%	92%	38%	83%	21%	0	52%
Semi-skilled labour	0	8%	0	10%	21%	52%	15%
Retired/unemployed	0	0	23%	0	35%	33%	15%
Government/salaried	20%	0	15%	7%	16%	4%	10%
Shop-keeper	0	0	7%	0	0	10	3%
Out-migrated	0	0	0	0	5%	0	1%
Priest	0	0	1.5%	0	0	0	0
Literate	63%	7%	61%	23%	40%	61%	43%
Disadvantaged ethnic group *	0	100%	0	100%	18%	65%	47%
Remittances	18%	8%	38%	20%	27%	3%	22%
Average landholding (ha)	1.3	0.2	0.6	0.35	0.2	0.0	0.4
Food stocks (months)	4.5	3.8	6.8	3.2	3.4	0.0	3.6
Monthly expenditures USD	98.1	44.1	74.9	70.3	119.2	116.6	82.7
Wedding expenditures USD	n/a	614.3	1428.6	n/a	2142.9	n/a	1995
Average number of livestock per household	4.6	1.7	2.5	2.3	1.7	0.7	2.2
Mobile tel.	81%	23%	69%	36%	70%	25%	51%
Electricity	100%	84%	100%	0	89%	95%	78%
In migration in past 30 years	9%	0	0	100%	70%	76%	43%
Migration reason	n/a	n/a	n/a				
Disasters				24%	39%	20%	28%
Economic reasons				48%	51%	71%	57%
Family reasons				28%	10%	9%	16%

Table 42. Demographics and economic data for all six study sites, n= number of surveys conducted, *according to NFDIN (2001)

6.1.2. Coping strategies, local knowledge, risk perceptions and community priorities

Mapping community coping strategies, perceived causes, preventive measures and perceptions of risk is critical for designing effective risk reduction programs (Anderson et al. 2011; Sudmeier-Rieux et al. 2011b). Consistent with other studies of Nepali local knowledge, we found a duality between a good understanding of environmental and geological causes of landsliding and flooding with supernatural causes (Bjornness, 1986; Gurung, 1989; Smadja, 1997) (Table 43). Most respondents in landslide-prone areas and Dharan mentioned rainfall as the main cause of landslides and flooding, whereas in flood-affected Punarbas, deforestation was mentioned as the main cause. In landslide affected villages, few preventive or corrective measures have been undertaken, whereas in flood-affected areas, dykes have been erected by local government for flood protection. We can group the six communities into two different types of groups, those who have engaged in some type of preventive or mitigating actions and those who have not, mainly due to development and food security priorities. As mentioned above, we note the presence of government for mitigating flooding near urban areas and their total absence for landslide mitigation.

Regarding coping strategies, or the range of options, adjustments, decisions or choices that households and communities use to deal with adverse situations (UNISDR, 2009a; Burton et al., 1993), the only community which was active in trying to find some solution to mitigating the landslide is Khariswara. It had organized itself into committees and as well as considering relocating their village to another site. The other high caste village, Sabra, has not undertaken any mitigation measures as the landslides affecting them were caused by road construction and very difficult to mitigate without major structural interventions. The other landslide affected villages are resigned to living in landslide prone areas, with few actions other than to accept this risk. Only 14-16% of respondents in three villages were likely to evacuate their houses in case of heavy rainfall, and the most active to monitor landslide activity (31%) are Khariswara residents, the most recent to experience landslides. The low number of respondents who actually evacuate during heavy rainfall is quite surprising considering the high belief (89%) that another landslide or flood is likely to occur. Thus there are few mitigation or evacuation measures or strategies and spite of very high risk perceptions.

Another common coping strategy is outmigration: as a direct cause of lost land, several men had migrated to Gulf countries, often leaving their families for periods of three years. This finding also confirms the push and pull trends toward out-migration, resulting in more vulnerable families during the husband's absence (Hoermann, et al., 2010). However, those families receiving regular high remittances are usually able to gradually secure better livelihoods. Also as mentioned above, the greatest percentage of outmigration comes from the better off communities as they are more likely to be able to afford to send their sons abroad.

	Sabra	Thang/ thang	Khariswara	Katahare	Punarbas	Dharan	Ave%
Causes of landsliding %							
Rain/drainage	64	38	38	24	n/a	n/a	36
Geology	7	7	31	17			17
Quarrying				34			17
Don't know	7	23	6	10			11
Gods are angry		7	25	5			8
Deforestation	14			7			6
River		23					4
Road construction	7			2			2
Causes of flooding %	n/a	n/a	n/a	n/a			
Urban run-off					32	32	32
Heavy rain					10	54	31
Deforestation					46	4	24
River encroachment					2	15	8
Lack of education					6		3
Landslides					4		2
Measures undertaken %							
No idea/ no capacity	100	75	54	97	13	47	53
Structural measures					86	52	42
Seek assistance			37				2
Discuss with neighbors		16	8	3			2
Plantation		8					1
What do you do when it rains? %							
Fear / stay at home	63	50	54	86	95	88	74
Monitor/ Try to prevent/ warn neighbors	37	30	31		5	12	18
Evacuate		16	15	14			8
Likelihood that another LS/flood will occur %							
Very likely	100	69	77	100	95	83	89
Somewhat likely		31	13		50	11	20
Not very likely						5	17

Table 43. Causes of landslides, flooding, coping strategies, risk perceptions.

6.1.3. Membership in social organisations

Table 44, “membership in social organizations” illustrates the importance of CFUG as the most important type of social organization among surveyed communities. It was the only social organization in Katahare and very important in Sabra and Khariswara, which both have important community forests. Management problems as reported by respondents in Thang/thang are also reflected in the low percent of community members participating in the CFUG. Instead, women's groups are quite successful in this village as well as in Khariswara. In both of these places, local NGOs have been working with women to establish such groups. Cooperatives can include groups that pool resources to provide business opportunities such as the purchase of livestock, sewing machines or other agricultural tools. In Thang/thang a couple of households belong to a local milk cooperative. Community based organizations can include other types of groups such as religious or youth groups. Savings groups are another form of social organization, or cooperative mainly found in the larger urban areas. Only one disaster committee was noted in one of the River neighborhoods of Dharan. It should be noted that social organizations can be very important for organizing disaster response even if established for a completely different purpose (Sudmeier-Rieux et al. 2011a)

	Sabra	Thang/ thang	Khariswara	Katahare	Punarbas	Dharan	Ave%
***Membership in social organisations%**							
CFUG	100	38	92	100	62	2	40
Cooperatives	100	23	77		55	43	30
Women's groups		69	46		36	22	18
Community Based Org.		23	23		2	28	8
Savings group					5	9.5	3
Disaster committee						5	1

Table 44. Membership in social organisations

6.1.4. Community priorities

Finally, it is important to understand household priorities in the context of landslide or flood mitigation (Table 45). If priorities are completely different than mitigation then it is likely that mitigation efforts will fail. This question was one of the most difficult to ask respondents during the survey and in-depth interviews. This is why we chose to ask it first as an open question, and secondly as a closed question providing the following options in this order: unemployment, flooding, electricity, earthquakes, drinking water, landslides, agricultural farming, skills training, health and sanitation, road access, access to land, community problems, education.

Our findings show that even communities at very high risk to future landslides and flooding, or which have very recently experienced a landslide are mainly concerned with development issues (access to land, roads, health, education, employment) with the exception of Dharan, which had also experienced a very recent flash flooding event. Thang thang, the poorest of the six communities, was clearly most concerned with access to land, education and improving their access to land, while roads were the primary priority for the other communities. It is not clear why Dharan respondents differed by a higher concern with flooding than development, perhaps due to a difference in interviewing, or due to the very violent nature of recent flooding, which is very likely to reoccur. Environment-related concerns refer to deforestation, quarrying and cleaner drinking water.

	Sabra	Thang/ thang	Khariswara	Katahare	Punarbas	Dharan	Ave %
Priorities %							
Open question							
Development related	81	100	100	93	62	17	51
Hazard related	19	54	42	23	19	58	34
Environment related				13		3	4
No response			15		19	12	11
Closed question							
Development related	54	46	15	26	73	56	52
Hazard related	46	54	46	73	26	35	44
Environment related						2	1
No response			39				3
Average							
Development related							52
Hazard related							39
Environment related							2
							7

Table 45. Household priorities for all study sites.

6.1.5. Impact of landslides on livelihoods[5]

In terms of livelihood strategies, one common strategy noted by respondents especially in Thang thang and Khariswara was to convert irrigated fields with valuable rice crops to lesser valued millet or wheat, as landslides damage irrigation or render a slope unsuitable for rice paddies. This has resulted in lost income, crops with lower nutritional value and a need to purchase this staple crop . In Sabra, there were fewer *khet* terraces due to the higher elevation, instead farmers had invested in cash crops, such as cabbage, cauliflower, cardamom and livestock.

Table 46 details substantial differences between communities, with a close correlation between average landholdings, food stocks and ethnic status. A majority of respondents in all communities have experienced some type of losses and damage to their houses and land. Lost land is especially striking, with an average of 75% of respondents having lost some land. Table 5 was developed using both our primary data and secondary data, mainly from the National Labour Force Survey 2008 (CBS, 2009b) and the crop monitoring survey from the Nepal Ministry of agriculture. We estimated mean household income from the CBS (2009b) data for mountain and Terai regions using average landholding per our surveys compared to data on average landholding giving is a ratio either above or below the average. This ratio than gave us the mean household income for each community surveyed. We include data on food stocks previous disaster

[5] Section submitted to World Landslide Forum II. Proceedings, Oct. 2-5, 2011 (Sudmeier-Rieux, et al. "A Neglected Disaster: Landslides and Livelihoods in Central-Eastern Nepal" In press)

experience, percent land damaged or lost in percent of *khet* converted to *bari* based on our survey data. Average yields of rice for the middle Hills was obtained from Nepal Ministry of Agriculture 2011. The cost of lost rice production was then estimated based on an average sale price of 40 NPR per kilo. Considering that most households have rebuilt their houses once or twice over 20 years, we estimated the cost of reconstruction for each location spread out over 10 years. We then obtained the average losses per community due to landslides. This figure is a rough estimate as are other costs that have not been included, such as the cost of reconstructing irrigation canals, roads, trails that may have been destroyed by landslides. By these estimates, landslides cause considerable economic damage, in the order of 50-30% of annual household income. This is a significant drain on household resources that could be used for other purposes such as improvement in agricultural productivity, education, purchase of new land. These figures are a first estimate and deserve further research for verification.

Landslide losses and livelihoods	Sabra	Thang/thang	Khariswara	Katahare
Average landholding per household (ha)	1.28	0.16	0.58	0.35
Average household landholding in VDC (ha)	0.7[6]	0.34[7]	0.50[8]	0.7[9]
Ratio as compared to average landholding	1.8	.47	1.2	.5
Mean household income for region (CBS, 2009b)	89,932	89,932	89,932	73,545
Mean household income based on landholding ratio	161,877	42,268	107, 918	36,772
Food stocks (months)	4.5	3.8	6.8	3.2
Previous dis experience%	100	100	69	76
House lost or damaged %	63	38	31	70
Land damaged or lost %	81	100	69	53
Percent of khet lost or converted to bari	0.30	0.50	0.75	0.45
Average rice yield kg/ha [10]	2,500	2,500	2,678	3,125
Lost annual rice production (kg)	960	200	1,164	169
Cost of lost annual rice production (NPR)[11]	38,400	8,000	46,560	6,760
Min. cost of house construction over 10 years(NPR)	10,000	8,000	10,000	5,000
Average annual loss due to landslides(NPR)	48,400	16,000	56,560	11,760
Percent of mean household income affected by landslides	29%	38%	52%	32%

Table 46. Cost of landslide losses compared to average household income.

[6] CBS, 2009b
[7] VDC profile data
[8] Idem
[9] CBS, 2009b
[10] Ministry of Agriculture, 2011
[11] Estimated at 40 NPR per kg

6.1.6. Impact of climate change on livelihoods

Three questions were added on climate change impacts at the end of the questionnaire. These questions were considered optional, as the questionnaire was already long and the concern was not to over burden respondents. Climate change impacts on livelihoods is also not directly a research question but as it is related to this study, research findings are presented here. The question was only asked anecdotally in Katahare and Sabra due to time constraints and more systematically asked in Thang thang, Khariswara, Dharan and Punarbas, with a total of 88 persons responding. Findings are presented for these four communities as they very much reflect anecdotal data collected from interviews and focus group discussions in Katahare and Sabra. Figure 133 illustrates responses to the first question on "Have you observed changes in the climate?" A majority of respondents answered "Yes the climate is changing" without specifying how. It is possible that this question was not properly translated. The second most common response was temperature increases with much hotter summers. However, changing rainfall patterns included both less rain or more rain or more intensive but shorter monsoon seasons. One resident from Thang thang described recent rainfall patterns as, "*the rains are becoming mad*".

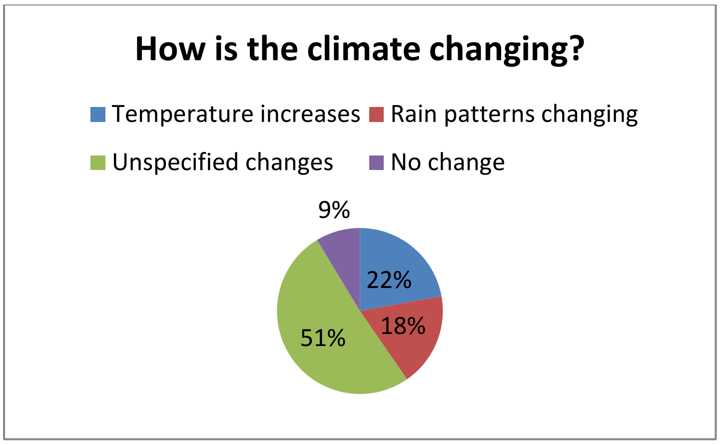


Figure 133. Responses to question whether any changes have been observed in the climate (Punarbas, Dharan, Khariswara, Thang thang) (Multiple responses were allowed, n=88).

Figure 134 illustrates responses on the second question on impacts of climate change to livelihoods. The greatest impact mentioned was to livelihoods, with 32% mentioning agriculture as the main impact, "our crop calendar is changing" "agricultural practices are traditional but the climate is changing so our practices are less productive". The second most important impact is on health, either malaria, child disease or other unspecified illness due to higher summer temperatures. Other impacts mentioned were higher occurrences of landslides and flooding. A full 27% felt that the changes in the climate had no impact on them, a majority of these people were respondents from Dharan. All of the "don't know" respondents were illiterate persons from Thang thang.

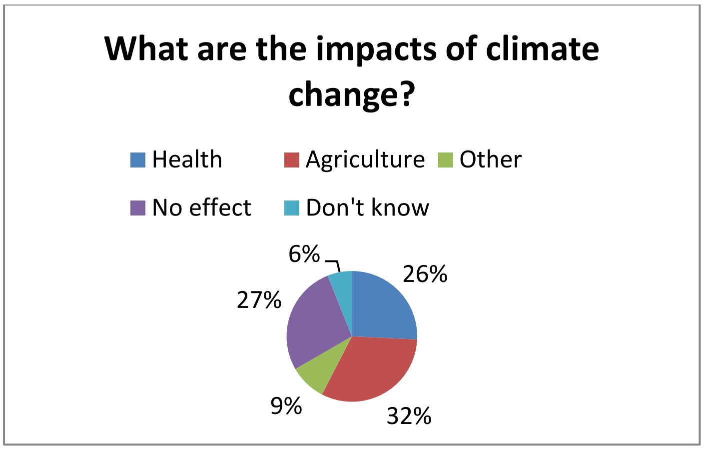


Figure 134. Responses to question whether any changes have been observed in the climate to livelihoods (Punarbas, Dharan, Khariswara, Thang thang villages) (Multiple responses were allowed) (n =88).

Figure 135 illustrates responses to the third question "Have you heard of climate change?". A majority, 57% of all respondents stated that they had not heard of climate change. Although a direct correlation has not been established, in general the most educated people were the ones to respond "yes". Thus, in spite of the fact that most respondents had noted significant changes in their environments, namely hotter summers and more intense rainfall, most of them had not heard of the term "climate change". These findings are consistent with other more thorough studies on the topic (Tse-ring et al., 2010). The ground reality of climate change is necessitating changes in agriculture practices, as more heat tolerant crops shift to higher elevations. Secondly, respondents mentioned health problems related to climate change, and last more climate related disasters, i.e. flooding and landslides.

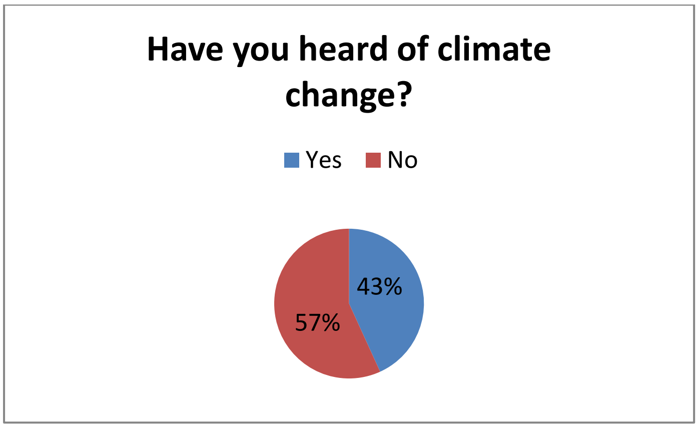


Figure 135. Responses to the question whether they had heard of the term "climate change" (for Punarbas, Dharan, Khariswara, Thang thang) (Multiple responses were allowed) (n =88).

6.2. Risk, vulnerability, resilience

This part of the results chapter presents the above descriptive and mainly qualitative data in more quantitative terms, first a quantitative measure of vulnerability , secondly a quantitative measure of resilience and third calculations of risk for each community.

The following section presents the results that analyze vulnerability and resilience on a methodological level data to answer two separate research questions, as described in section 1.3: *to what extent is resilience different from vulnerability or just its direct opposite; and which are the main factors of vulnerability and resilience that have the greatest impact on a community's ability to cope and mitigate landslide risk?*

6.2.1 Vulnerability assessments

As discussed in section 3.7.1.4. vulnerability is measured by different levels of resources: economic, physical, social, human, environmental, following the (UNISDR, 2009b) definition of vulnerability, our conceptual framework, the sustainable livelihoods approach and other similar approaches found in the literature (Bollin & Hidajat, 2006; Moench & Dixit, 2007). Resilience is measured by the resources needed during, or in the aftermath of an emergency to return to the pre-disaster state. These resources are also divided into different levels of economic, physical, social, human, environmental resources. With these data on vulnerability and resilience we thus present another set of descriptive data of the communities we studied.

Table 47. illustrates the 50 vulnerability indicators that were developed based on a review of the literature, field observations and stakeholder interviews.

Vulnerability Indicators (50)	
Economic resources (10)	**Social resources (10)**
Low food stocks < 3 months	No community leadership
Poor employment	No NGO assistance
No remittances	No Government assistance
Indebtedness	No women's groups
Low crop diversification	No CFUGs
Poor access to markets	No mutual assistance
No ownership of house	No cooperatives
No ownership of land	No regular (monthly) meetings
Few consumer durables	No extra kinship links
Few livestock	No savings groups
Physical resources (10)	**Natural resources (10)**
Inadequate water supply	Poor quality of forest resources
Poor sanitation	Poor water quality and quantity
No telephone or mobile	Low soil productivity
No electricity	Pollution of ground or air
Poor health care	No access rights to forest resources
Poor schools	No erosion protection
No access road	No awareness of landslide protection
No religious structures	Poor mgmt. of land for hazard protection
No structural hazard protection	Poor or no forest management
Poor house structure	Poor or no grazing management
Human resources (10)	
Population density	
Poor education <5 class	
No vocational skills	
No access to information	
No knowledge of hazard causes & prevention	
No organisational skills	
Household status	
Health/disabl/>70 yrs	
Ethnic group	
Female head	
Ratio working adults:dependents	

Table 47. Vulnerability indicators

Table 48 describes the vulnerability scores for each study site by type of resources. We note that Katahare and Dharan have the highest scores, just before Thang thang. Not surprisingly, Sabra and Khariswara, the communities with the higher ethics status, have the lowest vulnerability scores. Figure 136 illustrates that Katahare is largely vulnerable due to a lack of physical and economic resources; Dharan due to poor economic and natural resources; Thang thang due to poor access to most resources. Although these scores lack meaning on their own, they provide a useful means of comparison between study sites. They are consistent with the descriptive statistics presented in the previous sections, confirming the higher vulnerability of communities with low ethnic status and poor access to resources.

Vulnerability scores	**SABRA**	**THANG/THANG**	**KHARISWARA**	**KATAHARE**	**PUNARBAS**	**DHARAN**
Economic resources	14	19	15	21	18	21
Physical resources	15	20	20	26	15	16
Human resources	11	16	13	15	15	15
Social resources	12	19	11	16	14	18
Natural resources	16	20	13	18	19	26
TOTAL	68	94	72	96	81	96

Table 48. Vulnerability scores by type of resources

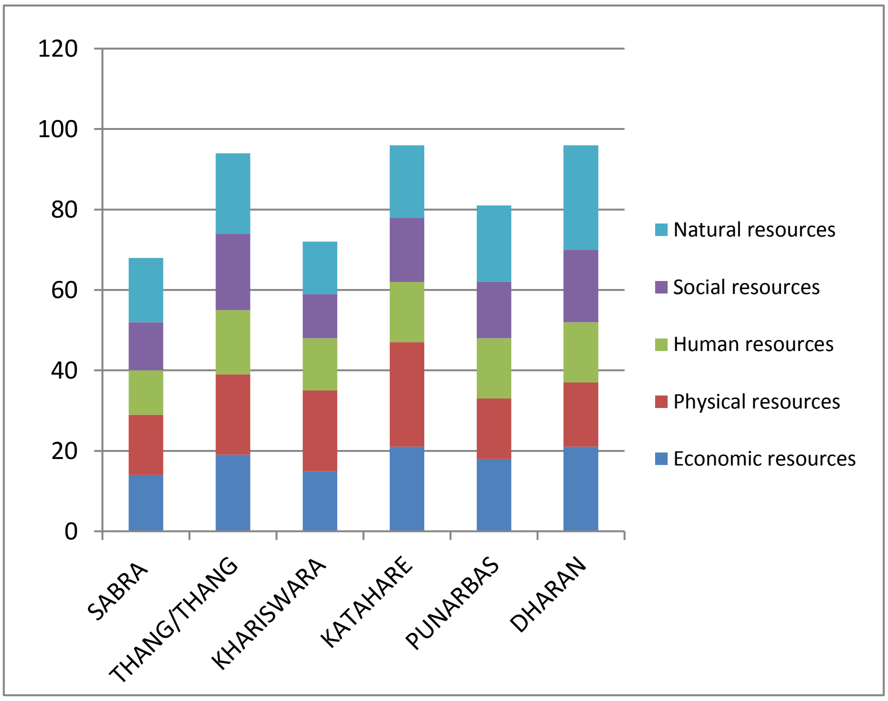


Figure 136. Chart of vulnerability scores by type of resources

Table 49 and Figure 137 present the same scores but in a different manner. Each type of resource is broken down by percentages to show which type of resources are most affecting each communities vulnerability score. For example, the lack of roads, electricity and sanitation in Katahare have resulted in a high physical vulnerability score. Although Khariswara's score is much lower, its lack of roads is what raised its physical vulnerability. Except for Katahare and Khariswara, all other communities have a greater percentage of vulnerability regarding natural resources, either due to more degraded resources or less well-managed community forests.

Vulnerability scores	Economic	Physical	Human	Social	Natural
PUNARBAS	22.2%	18.5%	18.5%	17.3%	23.5%
DHARAN	21.9%	16.7%	15.6%	18.8%	27.1%
KATAHARE	21.9%	27.1%	15.6%	16.7%	18.8%
KHARISWARA	20.8%	27.8%	18.1%	15.3%	18.1%
THANG/THANG	20.2%	21.3%	17.0%	20.2%	21.3%
SABRA	20.6%	22.1%	16.2%	17.6%	23.5%
(Highest %)					

Table 49. Vulnerability scores, break down by type of resource.

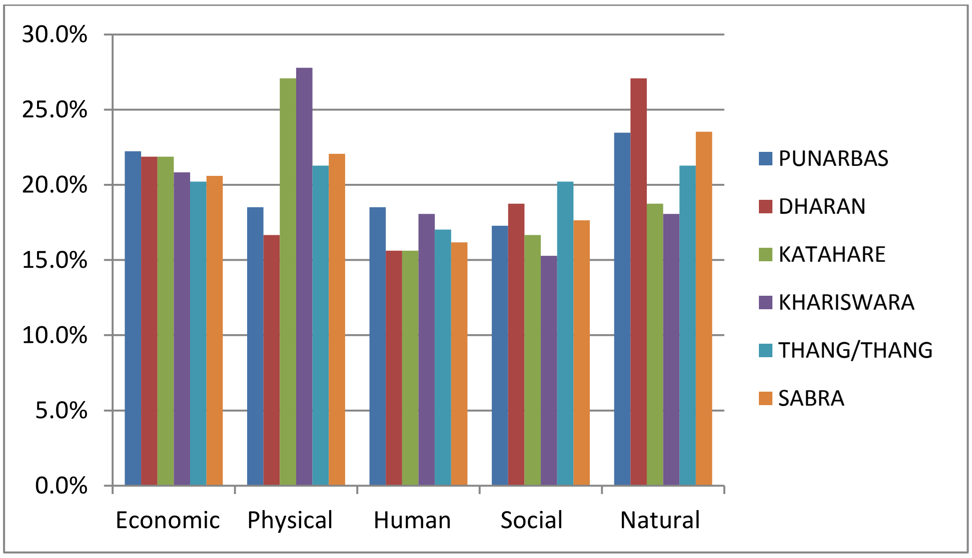


Figure 137. Chart of vulnerability scores, break down by type of resource.

6.2.1.1. Vulnerability mapping

As another way of representing vulnerability and as a guidance tool for prioritizing villages (i.e. for NGOs working on vulnerability reduction), we translated the above vulnerability scores for the four landslide affected communities into vulnerability maps. Since each household had been geo-referenced and assigned a vulnerability score, it was not difficult to transport this information into a GIS-based map. The following scale was chosen to enable a comparison between villages: high vulnerability = 150-100 score; medium vulnerability= 99-50 and low vulnerability 49-0. Different scales could be used within each village to better show differences at the village scale. Figure 138, Figure 139, Figure 140, Figure 141, illustrate vulnerability maps for landslide affected villages. The scaling chosen does not demonstrate a large variability within, or between villages. Not surprisingly, we note that villages and households with very low vulnerability correspond to the low income villages, Thang thang and Katahare.

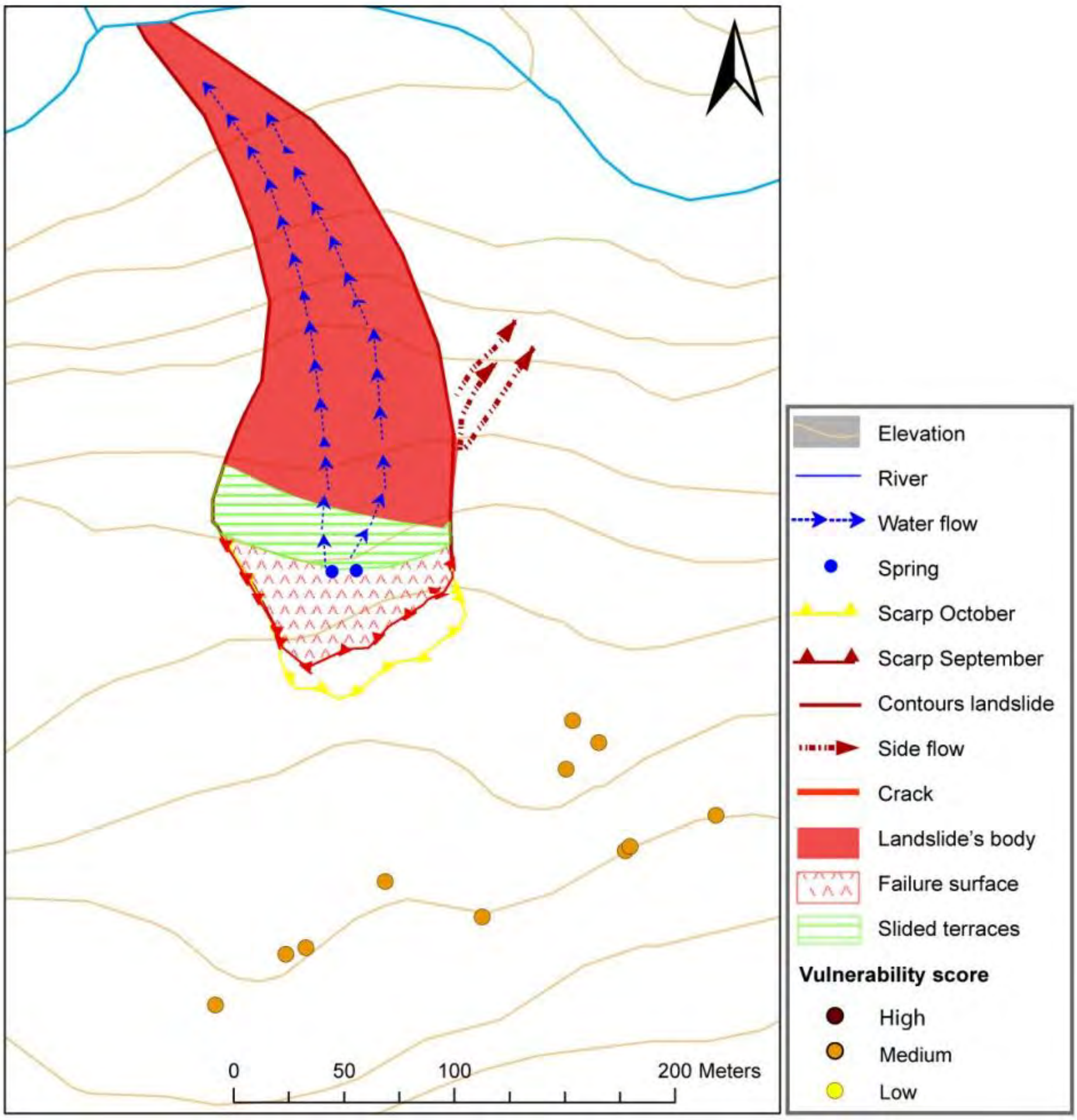


Figure 138. Vulnerability map for Khariswara (map by Jaquet, 2011d)

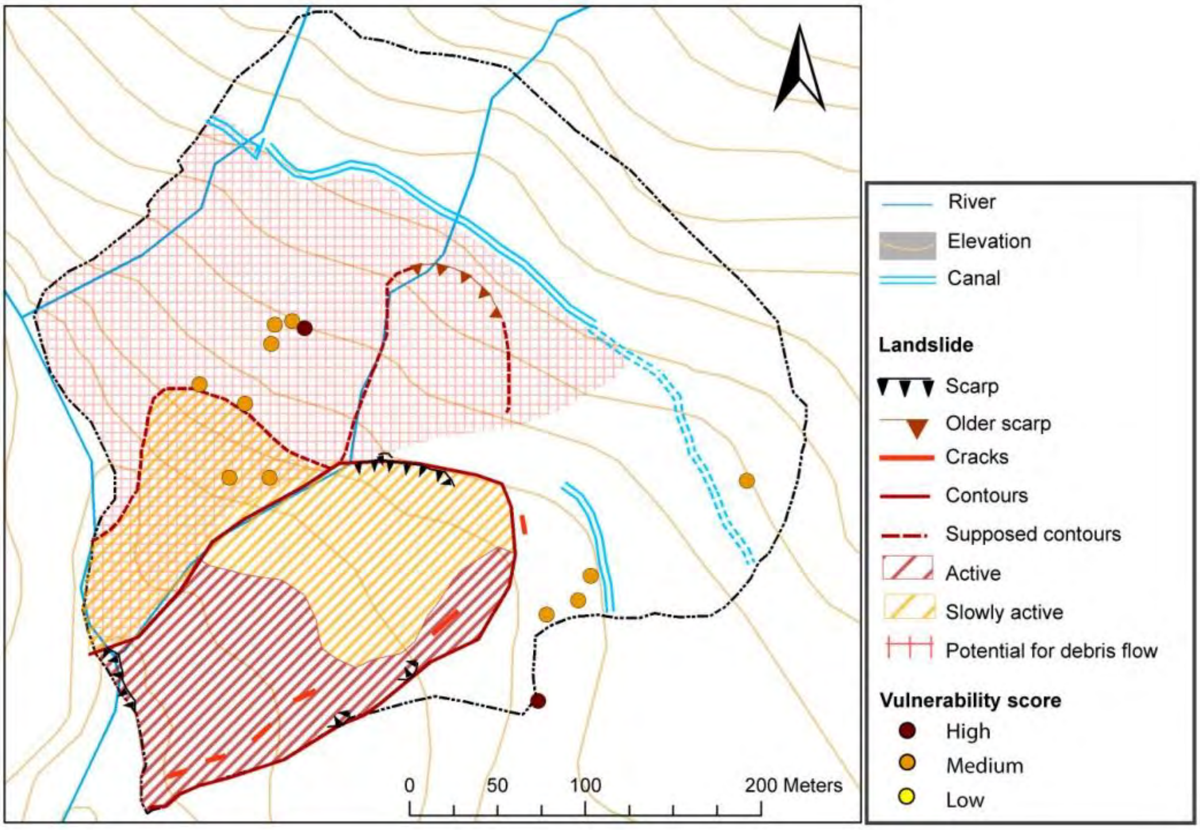


Figure 139. Vulnerability map for Thang thang (map by Jaquet, 2011d)

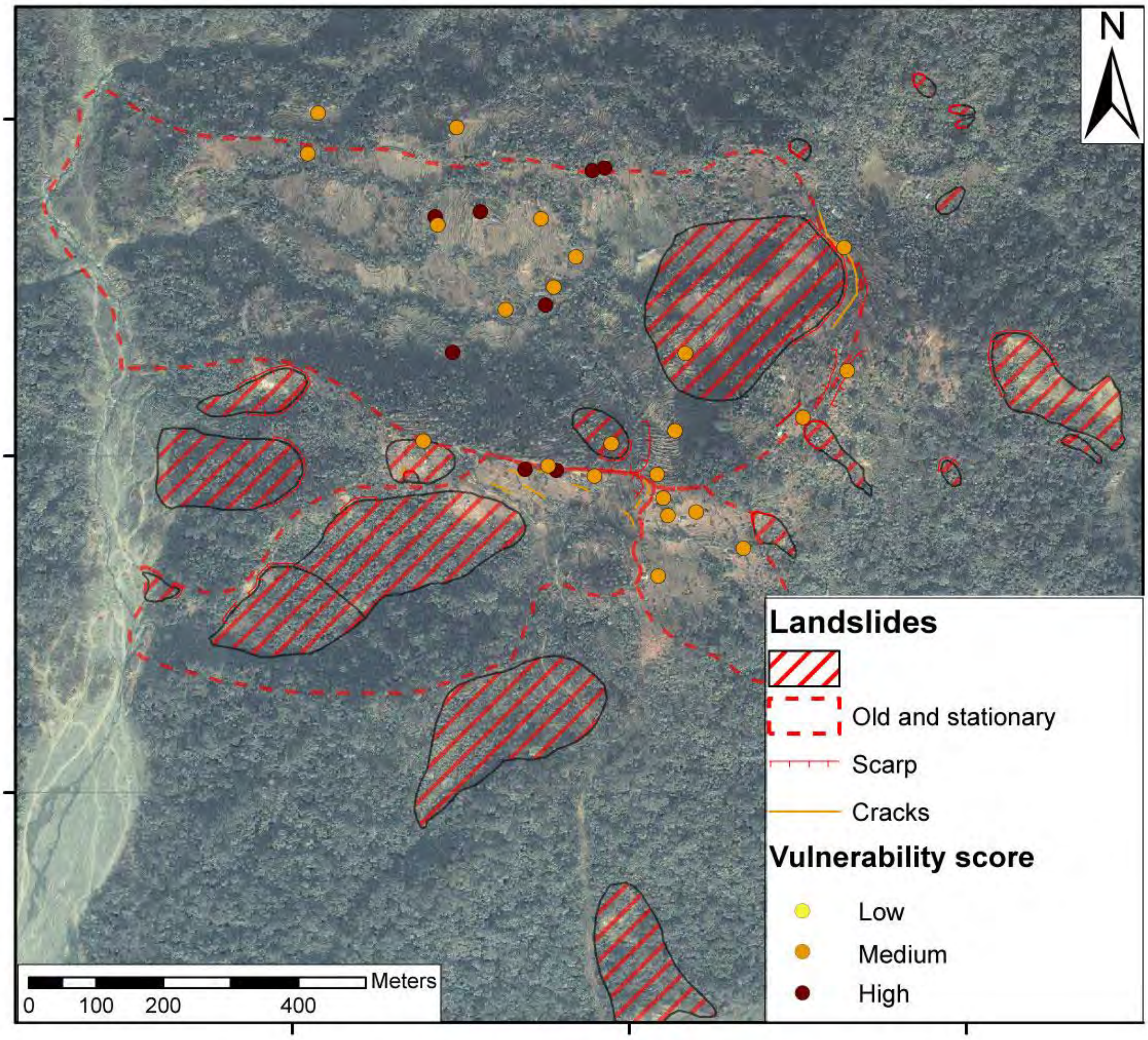


Figure 140. Vulnerability map for Katahare (map modified from Dubois, 2009 by Jaquet, 2011d)

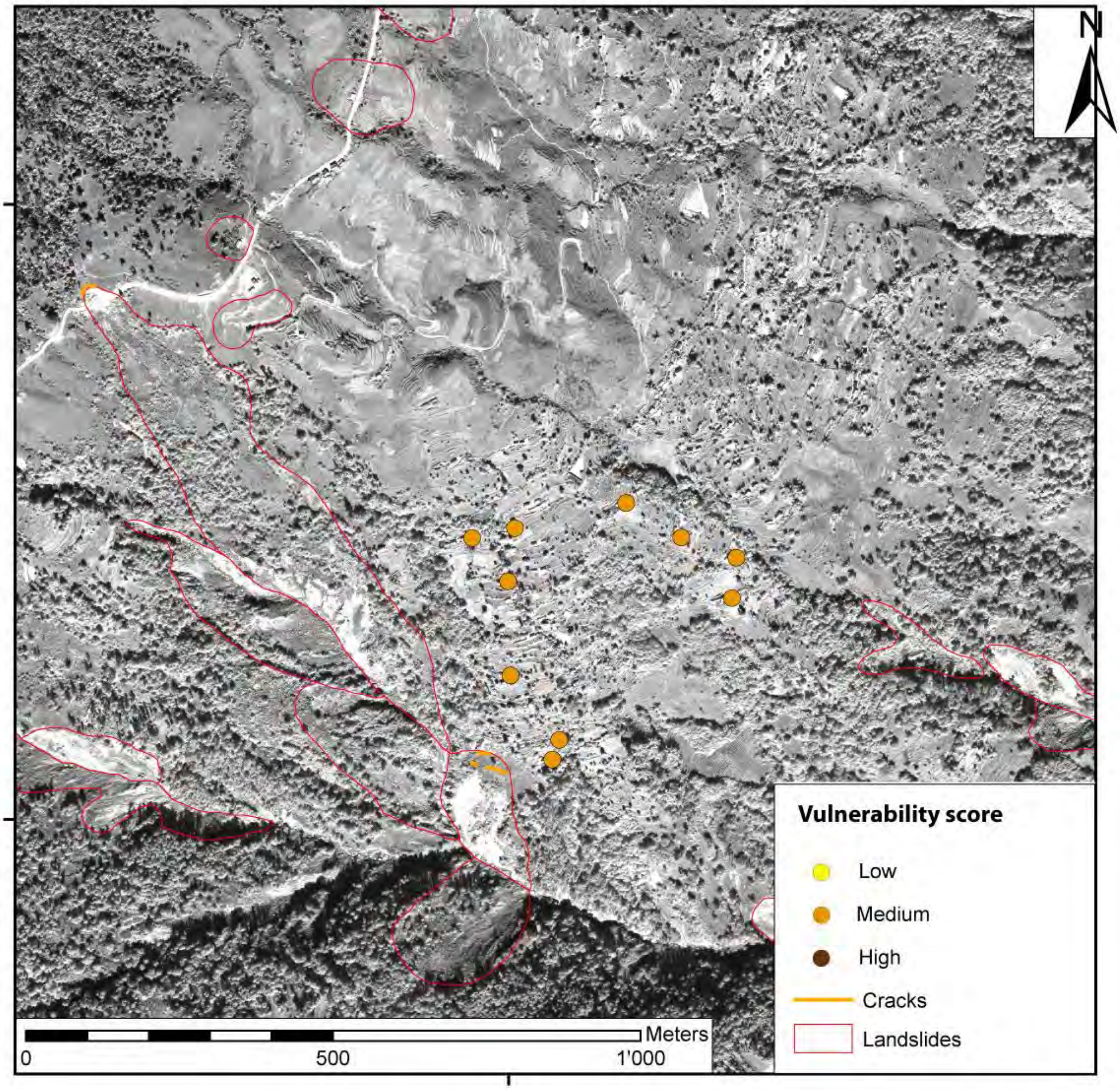


Figure 141. Vulnerability map for Katahare (map modified from Dubois, 2009 by Jaquet, 2011d)

6.2.2. Resilience assessments

As presented in the methodology section 5.7.1.4, 40 resilience indicators were developed based on our field observations and data to guide this method for measuring resilience (Table 50). As for the vulnerability indicators, each resilience indicator has the same weight. Each has been assigned a score from 0 to 3 with zero being the minimum and three the maximum. The maximum resilience score possible is thus 120. In spite of our theoretical conviction that resilience is not the opposite of vulnerability, a majority of indicators are actually the exact opposite, except for 8 indicators, highlighted in red.

Resilience Indicators (40)	
Economic resources (7)	**Social resources (10)**
Food stocks	Community leadership
Diverse income	NGO assistance
Remittances	Government assistance
Savings	Women's groups
Crop diversification	Community forest user group (CFUG)
Livestock in safe places	Mutual assistance
Consumer durables	Extra kinship ties
Physical resources (9)	Disaster management committee
Emergency water supply	Early warning system/monitoring
Telephone / Mobile	Evacuation plans
Access road	**Natural resources (4)**
Structural hazard protection	Good mgmt of land and forests
Adaptable house structure	Access and rights to forest products
Emergency health care	Good water quality
Helipad	Good forest quality
Safe building	
Access to tools/equipment	
Human resources (10)	
Population density	
Vocational skills	
Access to info (radios)	
Previous disaster experience	
Organisational skills	
Household status	
Health/disabl/>70 yrs	
Ethnic group	
Female head	
Ratio working adults:dependents	
First aid skills	

Table 50. Resilience indicators.

Table 51 and Figure 142 depict resilience scores for each of the six communities surveyed. A somewhat surprising finding is that Punarbas, a mixed ethnic community has the highest resilience score, followed by Sabra. This is surprising because we would have expected higher social status communities to have the highest scores, i.e. Sabra and Khariswara. We note that the high score for Punarbas is mainly due to its good access to physical resources and employment, whereas for Sabra, scores are overall relatively high. This finding is consistent with other studies that state that urban areas are more resilient to disasters (Klein et al. 2003). The lowest resilience scores are not surprisingly found in Katahare and Thang thang, the communities with the lowest ethnic status and economic opportunities. Katahare has very low scores for physical and economic resources, Thang thang's scores are very low for physical and natural resources, reflecting the poor access to infrastructure and poorly managed community forest.

Resilience scores	SABRA	THANG/THANG	KHARISWARA	KATAHARE	PUNARBAS	DHARAN
Economic resources	12	10	14	6	13	7
Natural resources	9	6	12	9	9	5
Physical resources	18	4	9	3	24	23
Social resources	18	17	22	11	19	15
Human resources	15	9	10	12	12	16
TOTAL	72	46	67	41	77	66

Table 51. Resilience scores by type of resource.

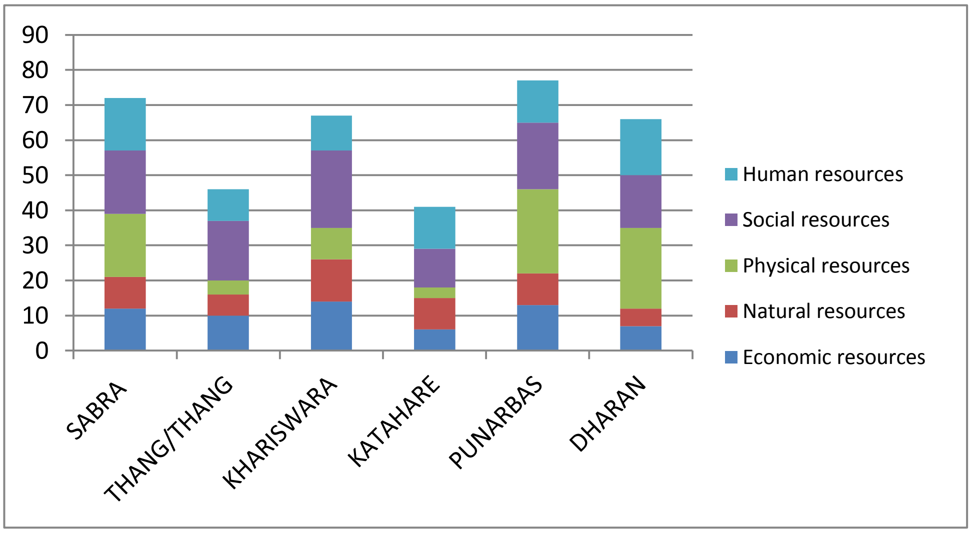


Figure 142. Chart of resilience scores by type of resource.

Table 52 and Figure 143 illustrate resilience scores with a breakdown by resource type. Not surprisingly, we note the high scores of physical resilience for the two urban areas. Sabra has high physical and social resilience scores. Thang thang and Khariswara have high social resilience scores, most likely because of the active women's group in Thang thang and the high membership of the Khariswara CFUG, as well as the presence of local NGOs in both these communities. Katahare's greatest score is for human resilience, due to combined experience and knowledge of previous disasters, and access to information as most households have at least one radio. As for the vulnerability scores, the caveat with the resilience scores is that they have little meaning out of context and are mainly useful for comparing with the other communities using the same survey method. As such, both the vulnerability and resilience scores do provide a crude, comparative measure of resilience by resource type, which can guide government or NGO interventions. For example, low resilience scores (Table 51) for human resources, indicates the need to invest in skills training and education; low resilience scores for economic resources, points to a need to invest in agricultural outreach and employment opportunities.

	Economic	Natural	Physical	Social	Human
SABRA	16.7%	12.5%	25.0%	25.0%	20.8%
THANG/THANG	21.7%	13.0%	8.7%	37.0%	19.6%
KHARISWARA	20.9%	17.9%	13.4%	32.8%	14.9%
KATAHARE	14.6%	22.0%	7.3%	26.8%	29.3%
PUNARBAS	16.9%	11.7%	31.2%	24.7%	15.6%
DHARAN	10.6%	7.6%	34.8%	22.7%	24.2%
Highest %					

Table 52. Resilience scores, break down by resource type.

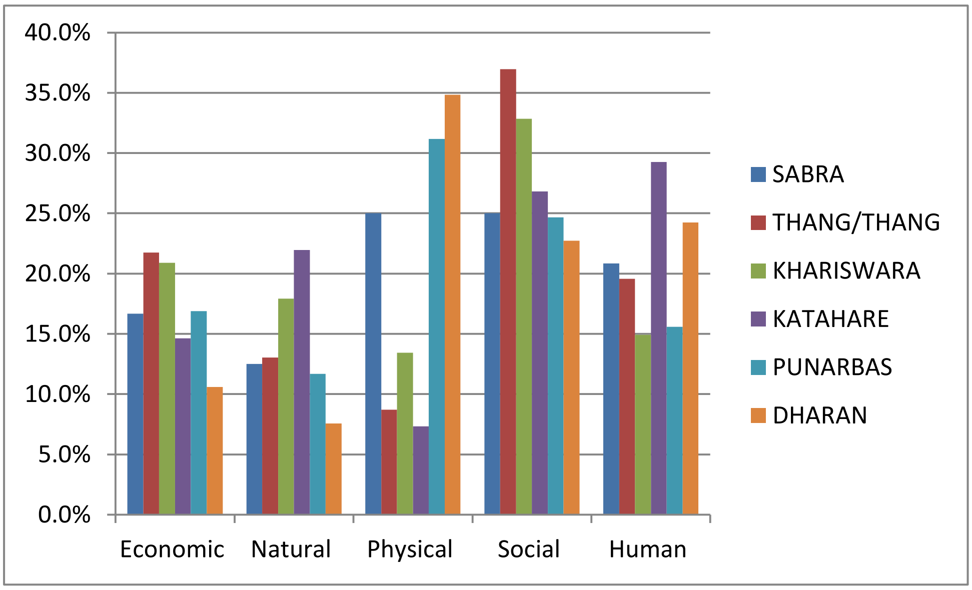


Figure 143. Chart of resilience scores, break down by resource type.

Figure 144 illustrates resilience and vulnerability scores for each community. Figure 145 illustrates the difference between resilience and vulnerability scores or their ratio. We note that Katahare has the highest difference between vulnerability and resilience, followed by Thang thang and Dharan. Khariswara, Punarbas and Sabra all have similar scores, Sabra is the only community with higher resilience than vulnerability scores. This is most likely due to their overall good access to resources mainly driven by their higher social status, education and economic levels. Figure 144 thus provides us with a good indicator of which communities should be prioritized for various types of interventions. This is the main purpose of developing such indicators of resilience and vulnerability.

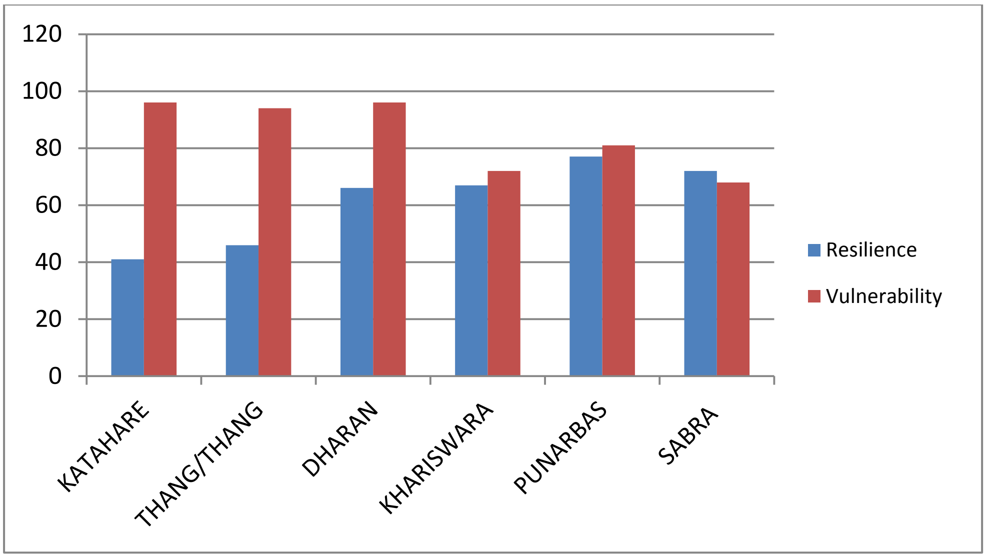


Figure 144. Chart of resilience and vulnerability scores.

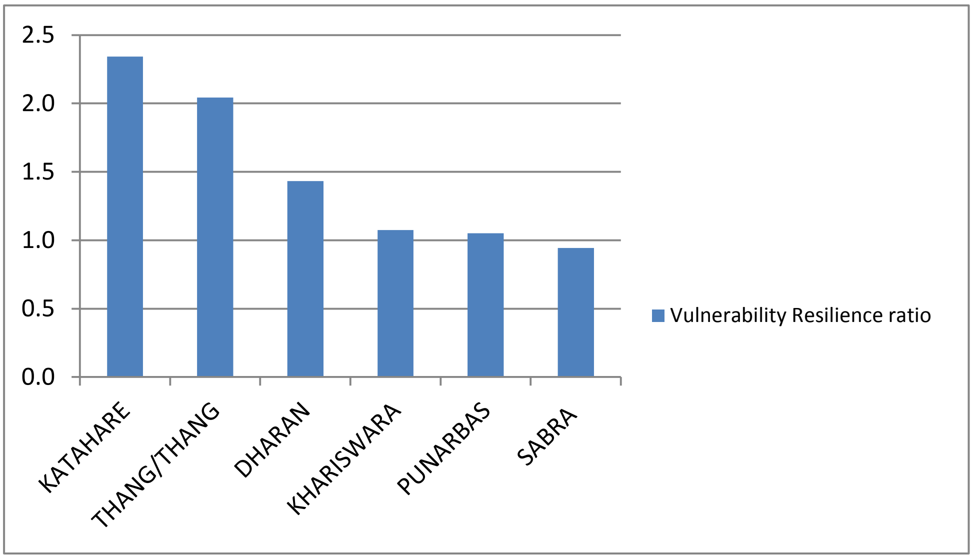


Figure 145. Chart of vulnerability resilience ratio, or the difference between the two.

6.2.2.1. Resilience mapping.

A similar mapping exercise (as for vulnerability mapping) was undertaken to compare resilience between villages (Figure 146, Figure 147, Figure 148, Figure 149). The scale used was again chosen to enable comparison between villages and not necessarily among households, although this would also be possible. High resilience = 120-90 score; medium resilience = 89-60; low resilience = 59-0. Again, we note that by using this scale we do not detect a large difference between the villages, not to mention within each village. However we are able to detect a greater number of low resilience households in Thang thang and Khariswara, reflecting almost the same households with high vulnerability in these villages.

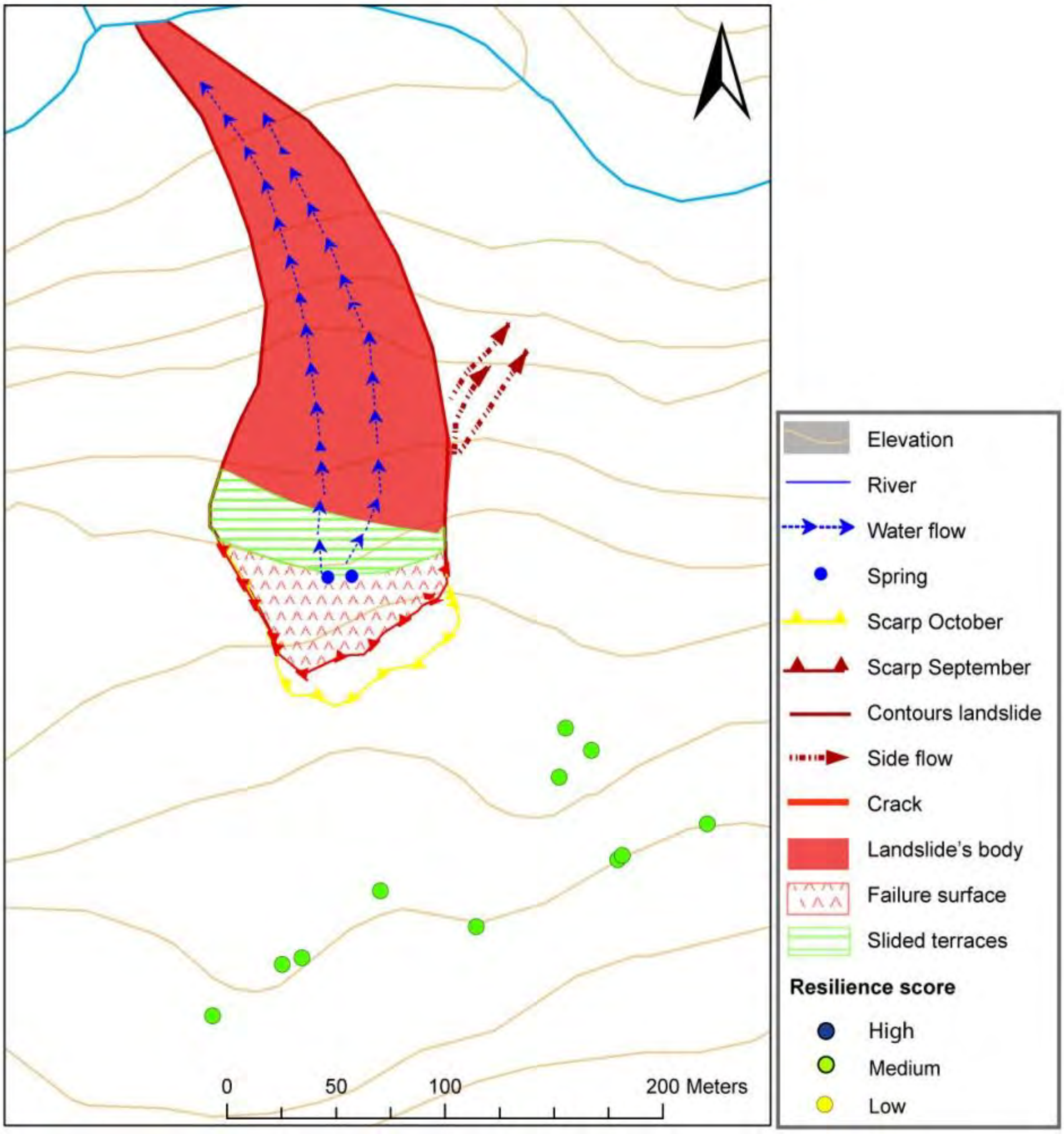


Figure 146. Resilience map, Khariswara (map by Jaquet, 2011b)

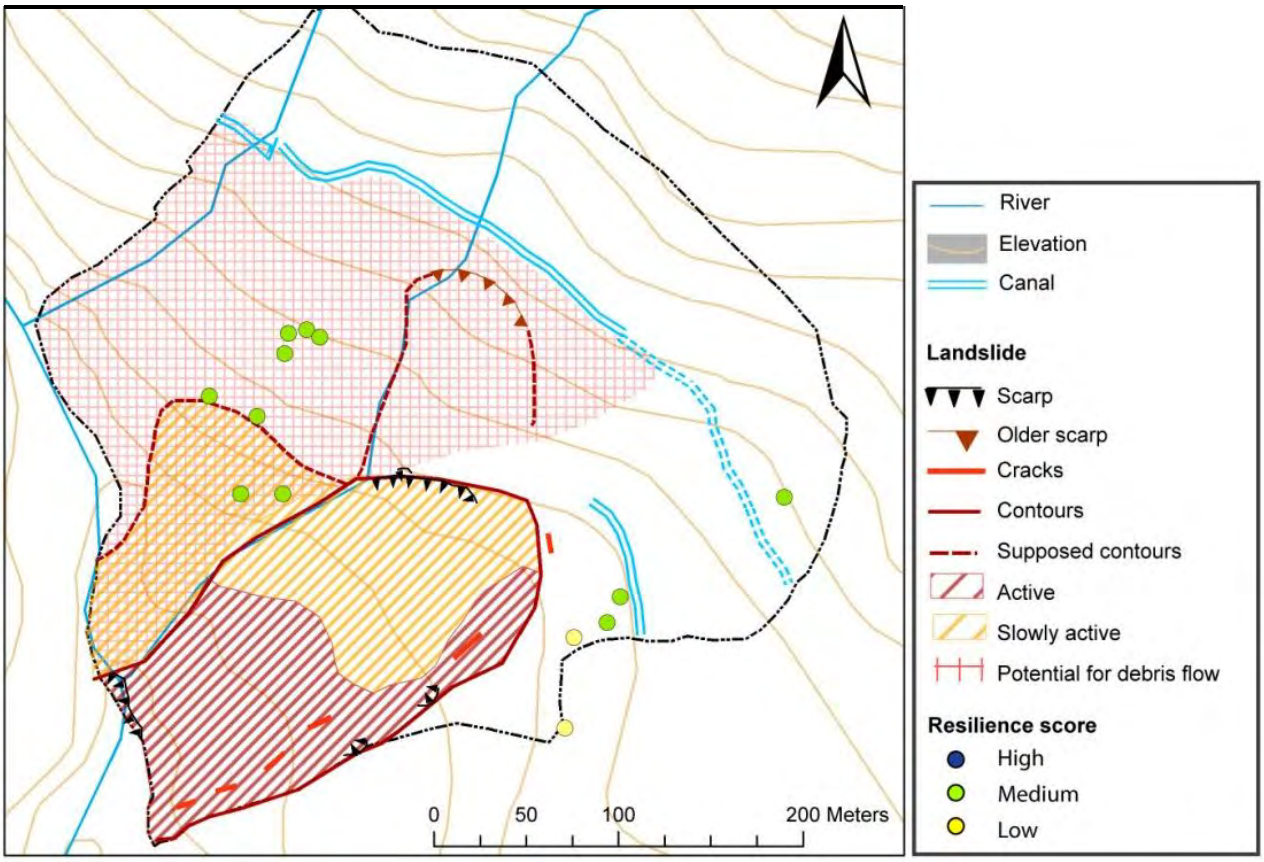


Figure 147. Resilience map, Thang thang (map by Jaquet, 2011b)

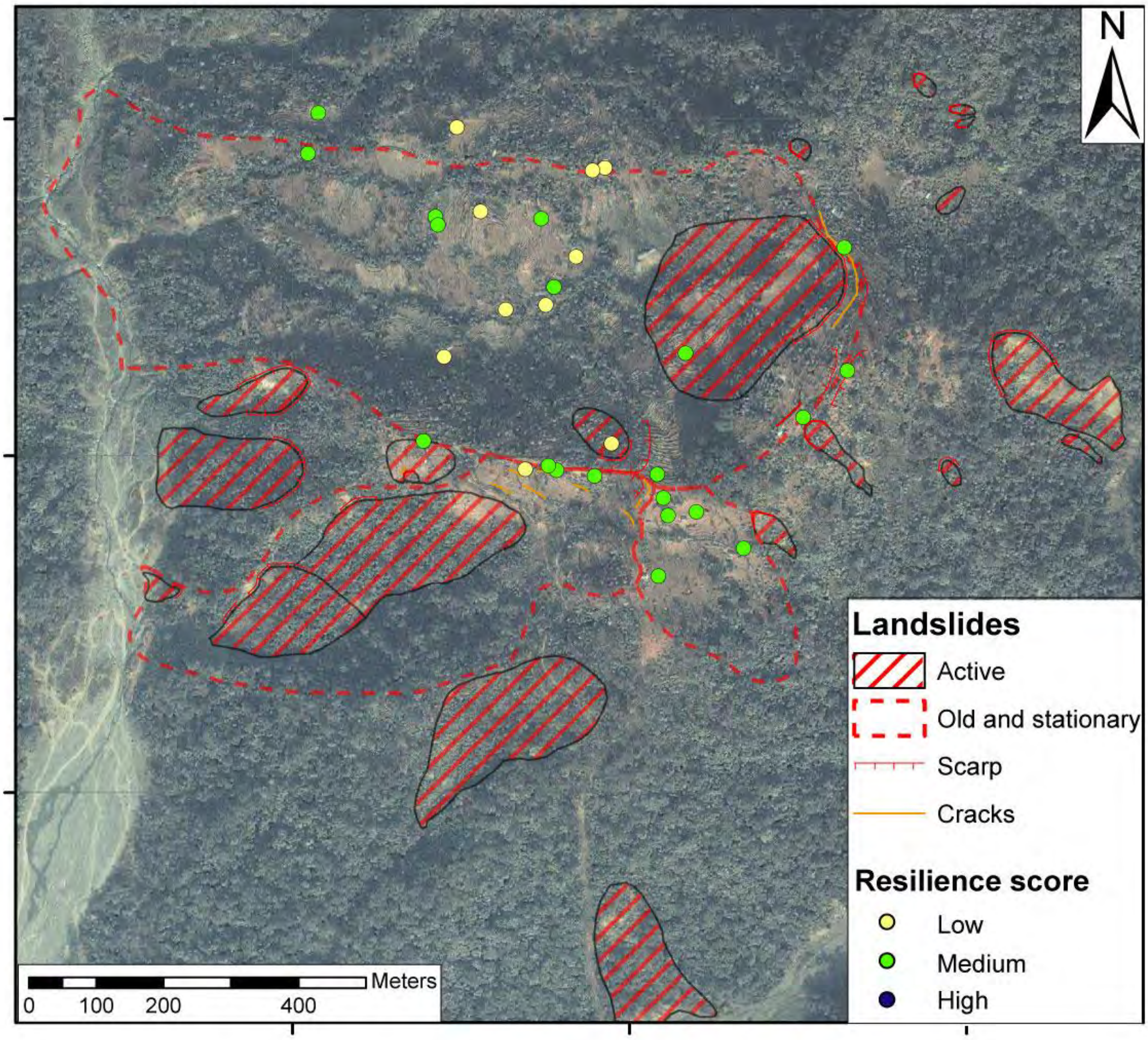


Figure 148. Resilience map, Katahare (map modified from Dubois, 2010 by Jaquet, 2011b)

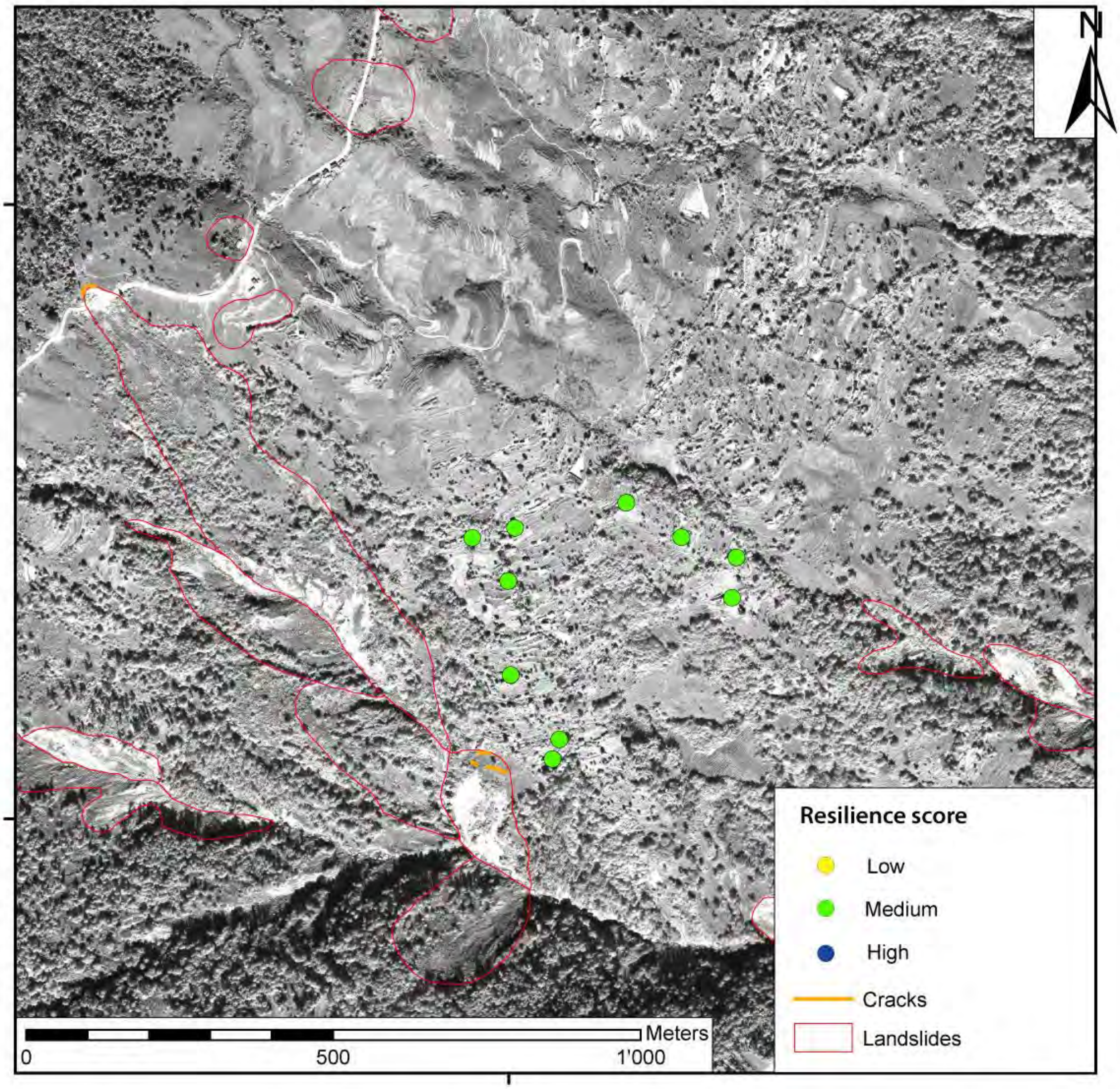


Figure 149. Resilience map, Sabra (map modified from Dubois, 2010 by Jaquet, 2011b)

6.2.3. Correlations between vulnerability and resilience

The purpose of the above section was to present our survey data in terms of vulnerability and resilience scores. Although the data are useful for indicating general trends and for comparing between communities, they did not answer one of our research questions about resilience : to what extent is resilience different from vulnerability or its direct opposite? To test the relationship between resilience and vulnerability indicators and whether there is an association between the two sets, we conducted several Pearson correlations, or the standardized regression coefficient using SPSS 19. Several analyses were conducted from a more general testing of the data in Figure 151 and Table 53. This result shows a statistical analysis of vulnerability and resilience scores averaged for all 6 locations together. Vulnerability is on the X axis and resilience on the Y axis, with a weak correlation (R^2= 0.4651) between the two sets of indicators. The low absolute values do not imply that the variables are not correlated but that the correlation is not a linear one (Agresti & Finlay, 1986). Normally R^2 scores above .70 or .80 can be considered correlated.

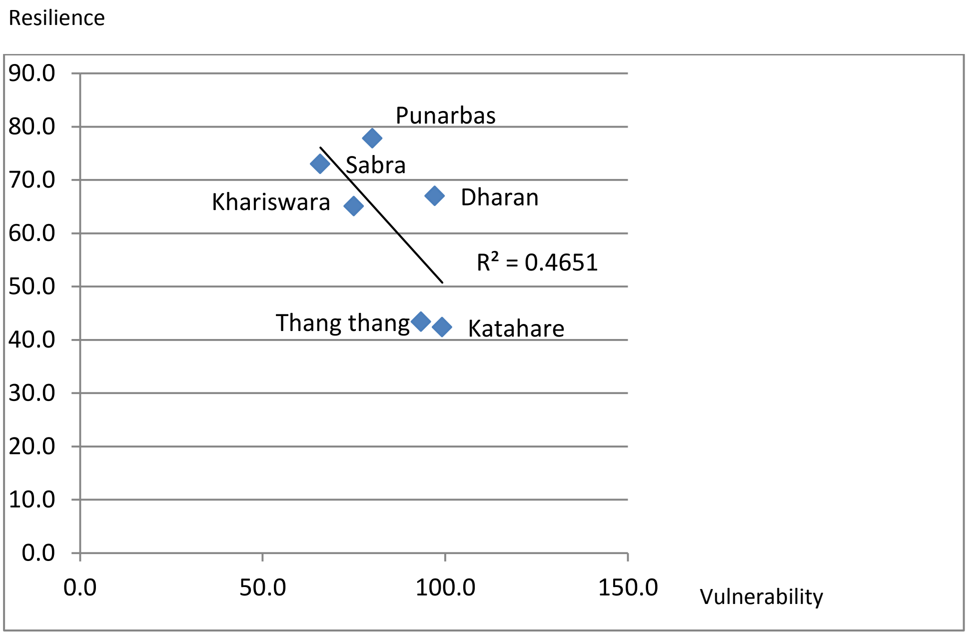


Figure 150. Pearson correlation averages of vulnerability and resilience for all 6 study sites.

	Sabra	Thang	Khariswara	Katahare	Punarbas	Dharan
Vulnerability	65.8	93.4	75.0	99.2	80.0	97.2
Resilience	73.0	43.4	65.1	42.3	77.8	67.0

Table 53. Averages of vulnerability and resilience scores for each locality.

A more detailed analysis is based on all 168 household scores by location (Figure 151,Table 54). Data tables for all following correlations can be found in Appendix IV. We note several clusters: flood affected locations have a higher level of resilience, most likely due to the developed physical structures as compared to the rural landslide prone locations. The lower bottom right cluster depicts the “poorer” landslide prone villages Katahare and Thang thang.

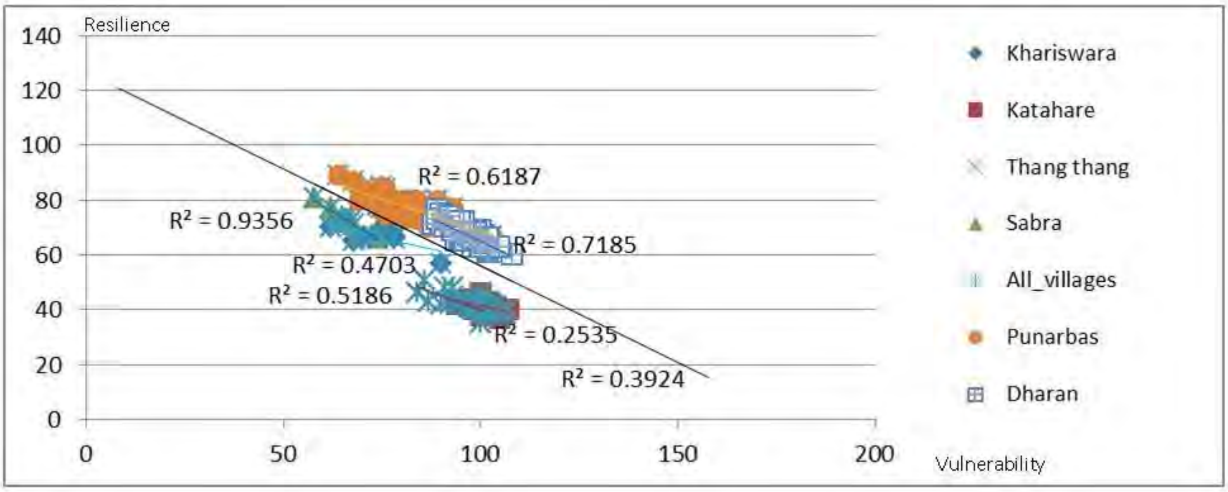


Figure 151. Pearson correlation between all locations surveyed.

All	Khariswara	Katahare	Sabra	Thang thang	Dharan	Punarbas
R^2 = 0.3924	R^2 = 0.4968	R^2 = 0.2535	R^2 = 0.9356	R^2 = 0.5186	R^2 = 0.7185	R^2 = 0.6187

Table 54. Pearson correlation results.

In this analysis, R^2 scores were obtained for each community in a range from 0.2535 for Katahare to 0.9356 for Sabra, the backward slope (0.3924) indicating negative correlations. Thus for the above correlations, only the Sabra and possibly, Dharan correlations can be considered to have a strong correlation. Figure 152 and Table 55 illustrate a similar correlation, this time with landslide affected and flood affected communities regrouped.

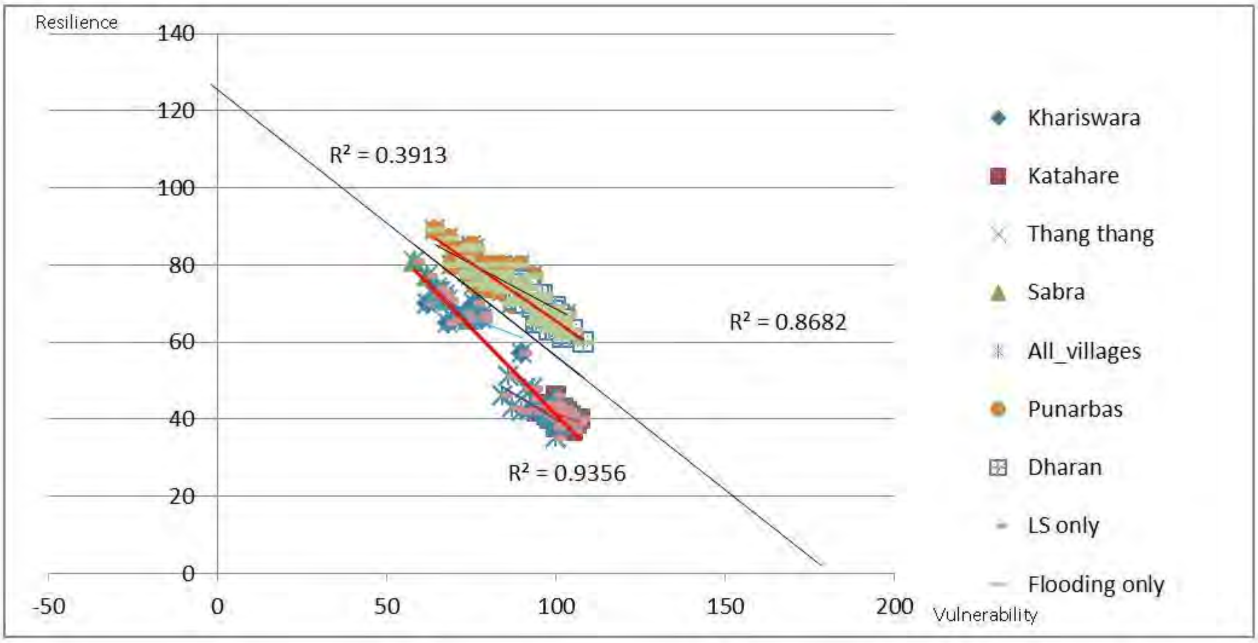


Figure 152. Pearson correlation with grouping of flood affected and landslide affected communities.

All	Landslide only	Flooding only
$R^2 = 0.3913$	$R^2 = 0.9356$	$R^2 = 0.8682$

Table 55. Pearson correlation with grouping of flood affected and landslide affected communities.

Again, we observe several clusters and differences between landslide in flood affected communities. Both of these grouped correlations are very high (R^2= 0.9356, R^2=0.8682) especially for the landslide affected communities. However there is little correlation for all six communities combined (R^2= 0.3913). This signifies that there are differing characteristics of vulnerability and resilience in flood affected versus landslide affected communities. Based on this finding, we can hypothesize that flood affected, urban communities are more resilient mainly because of their access to physical infrastructure, as well as some flood mitigation measures undertaken by local government. To test this hypothesis, a statistical analysis was undertaken, this time without the physical vulnerability or resilience data (Figure 153 and Table 56). Without the physical data, we find similar correlations for the flood affected and landslide affected areas however overall, both types of communities are more closely, although still weakly correlated, with a R^2 value of 0.6097. We infer that access to physical structures, such as in urban areas does increase resilience, a finding also confirmed by Klein et al. (2003).

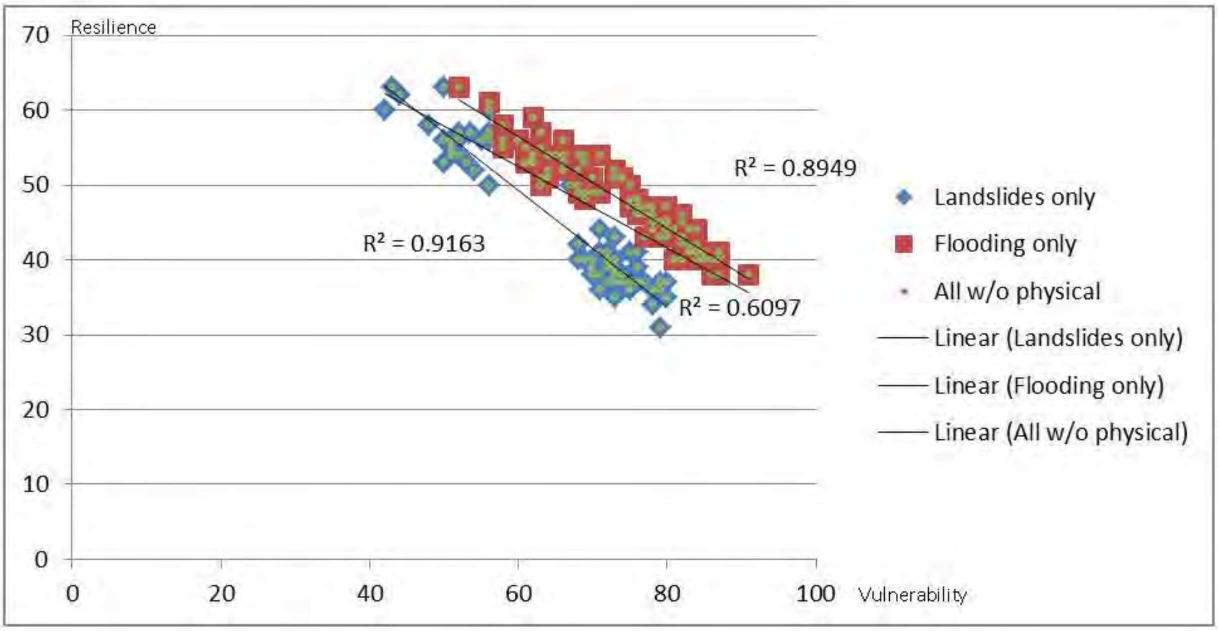


Figure 153. Pearson correlation with grouping of flood affected and landslide affected communities, without physical resources data.

All	Landslide only	Flooding only
$R^2 = 0.6097$	$R^2 = 0.9163$	$R^2 = 0.8949$

Table 56. Pearson correlation with grouping of flood affected and landslide affected communities, without physical resources data.

One more statistical analysis was conducted to test the importance of human resources for vulnerability and resilience (Figure 154, Table 57). This analysis also illustrates high correlations for flood affected communities and landslide affected communities separately (R^2= 0.9505 and R^2= 0.9030). We also see a larger spread especially between the clusters of landslide affected communities with the poorer Thang thang and Katahare in red on the bottom right, and wealthier Khariswara and Sabra in red on the top left.

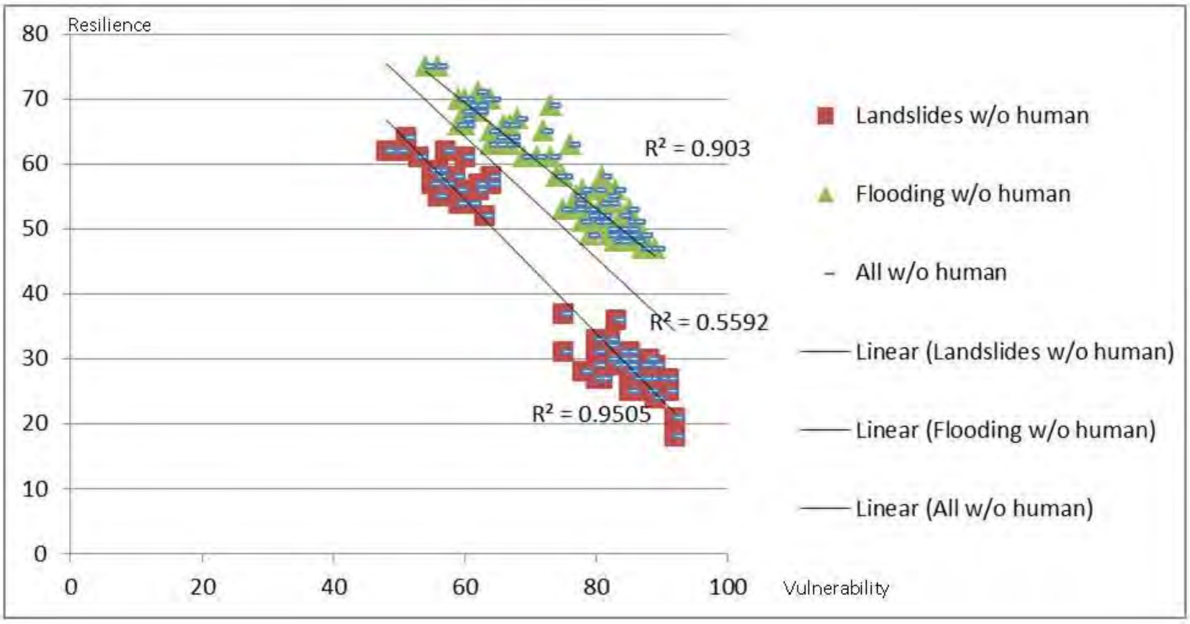


Figure 154. Pearson correlation with grouping of flood affected and landslide affected communities, without human resources data.

All	Landslide only	Flooding only
$R^2 = 0.5592$	$R^2 = 0.9505$	$R^2 = 0.903$

Table 57. Pearson correlation with grouping of flood affected and landslide affected communities, without human resources data.

Before concluding this section, one more heuristic test was conducted on the indicators in addition to the above statistical analyses (Appendix V). Vulnerability and resilience indicators (economic, physical, social, environmental, human) were compared in a "pivot table" with a value from -3 to +3 attributed to each intersecting variable, based on field experience. The value -3 corresponded to a max. negative correlation, and +3 corresponded to a max. positive correlation (e.g. "remittances" and "savings" are considered to have -3 correlation, while "access to telephone" and "water" had a 0 correlation). Following this test, we note that economic resilience and vulnerability indicators have the highest negative correlation, followed by environmental, social, human indicators and a low correlation between physical indicators of resilience and vulnerability.

Thus, in concluding this section, our findings do not provide direct clear answers about the relationship between vulnerability and resilience. We obtained very low overall R^2 scores when all data were combined and higher R^2 scores for separate clusters of landslide affected/rural areas versus flood affected/urban communities. These high correlations indicate a strong correlation in urban versus rural areas, which à priori reflects the type of indicators that were chosen for defining vulnerability and resilience. Again, out of 40 indicators of resilience, 32 were the direct opposite of vulnerability also reflected by the heuristic tests described above (Appendix V). However, our research shows overlap between vulnerability and resilience, making it necessary to clearly define each term and its scope. The analysis does however provide an interesting comparative analysis of resilience and vulnerability for urban areas affected by flooding, confirmed by Klein (et al. 2003) versus rural areas affected by landslides. The analysis underscores the need for more attention to be paid to rural areas for addressing vulnerability and resilience issues, especially with regards to landslides.

As it may not be practical for a local government agency or NGO to gather data on 50 indicators of vulnerability and 40 indicators of resilience, the next section analyzes which of these indicators were the most determinant and useful for the various types of analyses we conducted. This analysis differs from the previous section as it is not based on the same data base as described above, but is based on a heuristic method, easily replicated by local government or NGOs.

6.3. Convergence between vulnerability, resilience and risk

Until now we have mainly explored the relation between resilience and vulnerability and not how these two concepts relate to risk. We still only have partial answers to our research questions about vulnerability, resilience and risk: *To what extent is resilience different from vulnerability or just its direct opposite? And which are the main factors of vulnerability and resilience that have the greatest impact on a community's ability to cope and mitigate landslide risk?* In order to further explore these questions, a principal component analysis was developed but the results did not provide any useful information for our purposes. This is probably due to the large number of variables for which the principal component analysis did not show clear patterns. Instead other more pragmatic methods were developed that easily could be replicated and used by other researchers, NGOs or stakeholder groups who need to narrow down their range of indicators. The following tables thus follow a more heuristic method based on expertise to prioritize indicators. They are thus not based on the data set developed for the six case studies. As it is based on expert judgment, and not on a computer model, a certain amount of bias is possible. However, the advantage of the proposed method is its replicability and simplicity. Depending on stakeholder needs, the following exercises can be made quite participatory. Crosstabs were developed for each set of vulnerability indicators: economic, physical, human, social, environmental. The goal of this exercise is to define which variables are the most important by determining each variable's independence or dependence.

One example is given in Table 58 for economic vulnerability indicators, with independent variables placed on the horizontal axis and the same indicators placed on the vertical axis. Each variable on the horizontal axis was considered for its relative influence on variables on the vertical axis. Scores from zero being the minimum, to 3 being the maximum, were attributed to each case. For example, the influence of employment on food stocks is high, thus a score of three was attributed to this case. However, house values were not considered having a large influence on food stocks, thus the score 0. When we calculate all of the scores, we found that three independent variables have the greatest influence: employment, remittances, access to markets. The two most important dependent variables were food stocks and indebtedness.

INDEPT VARIABLE	FD SUPL	EMP	HOUSE VALU	LAND VALU	CRP DIV	CONS. DUR	LIVST	INDEB	RMT	MKT	
DEPEN											
FOOD SUPPLY	-	3	0	0	3	2	3	3	3	3	**20**
EMPLOYM	0	-	0	0	2	0	2	0	3	2	9
HOUSE VALUE	0	3	-	0	2	0	2	3	3	2	15
LAND VALUE	0	3	0	-	2	0	2	3	3	2	15
CROP DIV	0	3	0	0	-	0	3	2	3	3	14
CONS DURABLES	0	3	0	0	3	-	3	3	3	2	17
LIVESTK	0	3	0	0	3	0	-	2	3	3	14
INDEBT	3	3	3	3	3	3	3	-	3	3	**27**
REMITT	0	3	0	0	0	0	0	2	-	0	5
MARKETS	0	3	0	0	0	0	0	0	2	-	5
	3	**27**	3	3	18	5	18	18	**26**	**20**	

Table 58. Cross tabulation of economic vulnerability indicators, showing independent variables: horizontal axis and dependent variables on vertical axis.

The same exercise was conducted for all five categories of vulnerability variables, and the top two were selected from each. Table 59 shows that disadvantaged population, or ethnic groups followed by community leadership, employment/remittances, membership in CFUGs and poor forest resources are those vulnerability variables with the most influence. Poor water quality, employment/remittance, access to health clinics, roads, heath status are the most important dependent variables of vulnerability.

Independent variables	No Empl/ Remitt	Poor Road	Poor Health clinic	Poor Health status	Disadv pop	No Comm leader	No CFUG	No hzard prot	Poor forest resources	Poor water quality	Total
Dependent											
No Employ/ Remittances	-	3	2	3	3	2	2	1	2	2	**18**
Poor Road	2	-	3	2	3	3	2	0	1	0	**16**
Poor Health clinic	3	3	-	3	3	3	1	0	1	0	**17**
Poor Health status	2	3	3	-	3	2	1	0	2	3	**16**
Disadvantaged population	2	2	2	2	-	2	2	0	0	0	12
No Community leader	2	1	1	2	2	-	3	0	2	0	13
No CFUG	2	1	0	1	3	3	-	0	3	0	13
No hazard protection	2	0	0	0	3	3	2	-	3	0	13
Poor forest resources	1	0	0	1	2	3	3	3	-	1	13
Poor water quality	3	0	0	2	3	3	3	3	3	-	**20**
Total	**19**	13	11	16	**25**	**24**	**19**	7	17	7	

Table 59. Cross tabulation of top vulnerability variables.

Table 60 shows the same analysis for resilience variables. The most influential variables from each resource category were selected and cross tabulated. For resilience indicators, we find that belonging to a disadvantaged ethnic group, skills training, employment/remittances, membership of a disaster management committee and the existence of an early warning or monitoring system are the most influential independent variables. The most influential dependent variables are early warning or monitoring system , community leaders, CFUGs and hazard protection.

Independent variables	Empl/ Remitt	Disadv. Pop.	Comm leader	CFUG	Road	Hlth	Skills train	Hazard prot	Disaster mgmt	EWS/ Mon	Total
Dependent											
Employment/ remittances	0	3	1	2	2	2	3	1	1	1	16
Disadv population	2	0	1	1	1	2	2	1	1	1	12
Community leader	3	3	0	3	1	2	3	1	3	3	**22**
CFUG	3	3	3	0	1	2	3	1	3	3	**22**
Road	3	3	2	2	0	1	1	3	3	3	21
Health care	3	3	2	1	3	0	3	2	3	1	21
Hazard protection	3	3	2	2	2	1	3	0	3	3	**22**
Disaster management committee	3	3	3	3	0	1	3	2	0	3	21
EWS/Monitoring	3	3	3	3	1	1	3	3	3	0	**23**
Total	**23**	**24**	17	17	11	12	**24**	14	**20**	**18**	

Table 60. Cross tabulation of top resilience variables.

The following analysis (Table 61) looks at the role that the top 30 vulnerability indicators (selected based upon the preceding analyses) play for the various phases of a landslide event, which have been divided into prevention, during a landslide event and post disaster. Of course the following two tables are oversimplifications of reality, as with any model. Also for this exercise, a score was assigned from 0 to 3, depending on the level of influence each variable has for each phase of a disaster. For example, healthcare was considered to have the maximum influence in the prevention, during an event, and post disaster. What is missing from this exercise is some measure of magnitude and thresholds. In other words, vulnerability and resilience will not be the same for a small versus very large hazard events. Therefore if replicating this exercise, it is important to specify the type of hazard event, and if possible the magnitude, as both vulnerability and resilience need to be defined in terms of the specific context, i.e., the population may be resilient to small earthquakes but not large landslides. Eighteen variables received the maximum score, and are mostly the same most influential variables as illustrated in Table 59.

INFLUENCE OF VULNERABILITY INDICATORS ON A LANDSLIDE EVENT	Prevention (pre-event)	During event	Recovery (post-event)	Sum
No Food stocks	1	3	3	7
Low income diversity	3	3	3	**9**
No Water supply	1	3	3	7
No Sanitation	1	3	3	7
No Telephone/mob	1	3	3	7
No Health clinic	3	3	3	**9**
Poor House structure	3	3	3	**9**
No Vocational skills	3	3	3	**9**
No Access to information	3	3	3	**9**
No Knowledge of hazards	3	3	3	**9**
No Organizational skills	3	3	3	**9**
Poor Health status	3	3	3	**9**
Disadvantaged ethnic group	1	3	3	7
Female headed household	3	3	3	**9**
No Community leader	3	3	3	**9**
No NGO/Govt assistance	3	3	3	**9**
No Women's group member	3	3	3	**9**
No CFUG membership	3	3	3	**9**
No Mutual assistance	3	3	3	**9**
No Cooperatives	2	3	3	**8**
No Regular meetings	3	3	3	**9**
No Extra kinship ties	1	3	3	7
Poor Quality of forest resources	3	3	3	**9**
Poor Water quality and quantity	3	3	3	**9**
No Access rights to natural resources	1	3	3	7
No Erosion protection	3	1	3	7
No Awareness of protection measures	3	1	3	7
No Management of land for hazard protection	3	1	3	7
No Forest management	3	1	3	7
No Grazing management	3	1	3	7

Table 61. Influence of vulnerability variables for all phases of a landslide event.

The same analysis has been conducted for resilience variables and their influence on a land slide event (Table 62). Twenty variables of resilience received a top score, many of which are the same variables as identified above, providing a validation of previous findings. Both the resilience and vulnerability variables had a greater influence on the period during the hazard event and post disaster .

INFLUENCE OF RESILIENCE VARIABLES ON A LANDSLIDE EVENT	Prevention(pre-event)	During event	Recovery (post-event)	Sum
Food stocks	1	3	3	7
Diverse income	3	3	3	**9**
Remittances	3	3	3	**9**
Savings	3	3	3	**9**
Livestock in safe places	1	3	3	7
Emergency water supply	1	3	3	7
Telephone / Mobile	1	3	3	7
Access road	1	3	3	7
Structural hazard protection	3	3	3	**9**
Adaptable house structure	3	3	3	**9**
Emergency health care	1	3	3	7
Access to tools/equipment	3	3	3	**9**
Helipad	1	3	3	7
Safe building	1	3	2	6
Vocational skills	1	3	3	7
Access to info (radios)	3	3	3	**9**
Previous disaster experience	2	3	3	8
Organisational skills	3	3	3	**9**
Health/disabl/>70 yrs	3	3	3	**9**
Ethnic group	3	3	3	**9**
Female head	3	3	3	**9**
Ratio working adults:dependents	3	3	3	**9**
First aid skills	1	3	3	7
Community leadership	3	3	3	**9**
NGO assistance	3	3	3	**9**
Govt assistance	3	3	3	**9**
Women's groups	3	3	3	**9**
Community forest user group (CFUG)	3	3	3	**9**
Mutual assistance	3	3	3	**9**
Extra kinship ties	3	3	3	**9**
Disaster mgmt committee	3	3	3	**9**
Early warning system/monitoring	3	3	1	7
Evacuation plans	1	3	1	5
Good mgmt of forest resources	3	1	3	7
Access and rights to forest products	1	3	3	7
Good water quality	1	3	3	7
Good forest quality	3	1	3	7

Table 62. Influence of resilience variables for all phases of a landslide event.

One more exercise was developed to test the relation between vulnerability variables and various phases of risk (Table 63). It could easily be transformed into a checklist in preparing a baseline study on community risk due to landslides in this case to determine which type of interventions are most needed, or should be avoided to reduce risk. Twenty-eight vulnerability variables were selected for this exercise; most variables actually increase risk, especially those highlighted in red. The road is an interesting variable in the context of landslides, as it physically increases landslide hazards in many cases and people's exposure while reducing their vulnerability by providing easier transportation (i.e. for healthcare). Population density is another one, where high population density could increase the landslide hazard and exposure by constructions that can cut slopes and place people in 'harm's way' (i.e. high density slum areas on slopes near urban areas). However, we also observed that higher density areas tend provide better access to infrastructure, health, education , etc. and receive more attention for mitigation, thus reducing vulnerability. This exercise was not developed for resilience indicators because of our definition of resilience as being time and resources necessary for recovery after a hazard event, not for reducing risk. Thus resilience reduces the overall cost of a disaster and the post disaster phase but will not necessarily reduce risk.

Vulnerability Variables Impact on Risk due to Landslides [-3…+3]	Hazard	Vulnerability	Exposure	Total
No Employment	1	3	1	5
Indebtedness	1	3	1	5
No Remittances	1	3	1	5
Poor Health	0	3	2	5
Road	3	-2	3	4
No Structural protection	3	3	3	9
Population density	2	-3	3	2
No Education	0	3	3	6
No Skills training	0	3	3	6
No Access to information	1	3	3	7
No Knowledge of hazard	1	3	3	7
No Organizational skills	2	3	3	7
No NGO/Govt assistance	3	3	3	9
No Community leader	2	3	3	8
No CFUG	2	2	2	6
Poor Quality of forest resources	2	2	2	6
Poor Water quality and quantity	1	3	3	7
Poor Soil productivity	0	3	2	5
No Access rights to natural resources	1	3	2	6
No Erosion protection	3	3	2	8
No Awareness of protection measures	2	2	2	6
No Management of land for hazard protection	3	3	3	9
Poor Forest management	3	3	2	8
Poor Grazing management	3	3	3	9

Table 63. Vulnerability variables impact on risk due to landslides.

The last table (Table 64) provides guidance on the cost-effectiveness of risk reducing interventions based on findings in Table 63. The idea is to propose a simple methodology that can be used for decision-making on which types of interventions are the most cost-effective for reducing landslide risk. Using the total from the above scores (risk impact) and dividing by the estimated hypothetical costs (scale from 1 to 3) of each type of intervention, we can obtain scores of cost-effectiveness ranging from 1 to 4.5. Hypothetical costs were estimated as highest for structural interventions, such as road building or structural protection or reducing employment, while investment in human resources and natural resources management were considered of medium cost. Nine interventions were considered the most cost-effective for this exercise, i.e., community leadership, improving natural resource management, organizational skills and improving access to information. This exercise would have more meaning if using actual numbers and could be the subject of future research.

Cost-effectiveness of various interventions for reducing risk [-3…+3]	Impact on risk /	Cost =	Cost effectiveness
Employment	5	3	1.67
Indebtedness	5	2	2.5
Remittances	5	2	2.5
Poor Health	5	2	2.5
Road	4	3	1.3
Structural protection	9	3	3
Population density	2	2	1
Education	6	2	3
Skills training	6	2	3
Access to information	7	2	3.5
Knowledge of hazard	7	2	3.5
Organizational skills	7	2	3.5
Community leader	8	2	4
CFUG	6	2	3
Quality of forest resources	6	2	3
Water quality and quantity	7	2	3.5
Soil productivity	5	2	2.5
Access rights to natural resources	6	2	3
Erosion protection	8	2	4
Awareness of protection measures	6	2	3
Management of land for hazard protection	9	2	4.5
Forest management	8	2	4
Grazing management	9	2	4.5

Table 64. Cost effectiveness of vulnerability variables for reducing risk due to landslides.

To sum, this chapter presented all the results for the case studies, mainly of landslide affected communities; comparative descriptive data on the case studies with some data on landslide affected communities; a quantitative approach to vulnerability and resilience based on data from our case study research; and finally a methodological analysis of resilience to better understand its scope, limitations and present several guidance tools for making this concept more operational. The next chapter, discussion, will analyze in more detail whether these results answered all of the research questions and the extent to which hypotheses can be confirmed.

Discussion

This chapter is intended to verify whether general research questions were answered, research objectives were met, and hypotheses verified in addition to a general discussion about this study.

7.1 Research objectives

Research objectives were designed to answer specific research questions, addressed in detail in the two previous chapters on results. The first objective: to define and distinguish factors and relationships between resilience, vulnerability, coping strategies and risk as a basis for improving community-based disaster risk reduction strategies for landslide affected communities in Eastern Nepal, became clear once the sustainable livelihoods framework was established as the conceptual framework for the study. This choice of a conceptual framework was justified by a similar approach used by (Mayunga, 2007; Twigg, 2010; Cutter et al. 2009; Cutter et al., 2010). In order to meet this objective the study was designed to understand risk by combining a geological, environmental and socio-economic assessment of vulnerability; coping strategies mainly through focus group discussions and participatory social mapping exercises; vulnerability and resilience by combining household questionnaires with semi structured interviews. Research findings did meet this objective, as presented through the development of six case studies with various levels of risk, vulnerability, resilience and coping strategies in the comparative results section.

The second objective: to develop an operational framework for measuring resilience and vulnerability as a guidance tool for directing interventions for reducing landslide risk in central and Eastern Nepal; was quite a long and iterative process, first based on a thorough literature review, field observations and stakeholder discussions to identify indicators of resilience and vulnerability. For this, Twigg's 'Disaster Resilient Communities' publication (Twigg, 2010) was of particular inspiration yet considered difficult to operationalize as it is very much based on a qualitative approach. The advantages and disadvantages of a quantitative approach to measuring resilience were contemplated. As the goal was to develop a guidance tool for comparison between communities, a decision was made to develop a quantitative method for measuring resilience. The decision was inspired by the Chambers 2007 publication 'Participatory numbers', which encouraged more research combining qualitative and quantitative participatory research. Indicators of resilience and vulnerability were again based on existing literature field tested with Nepal expert advice and community feedback. Inspiration was also found in Cutter et al. 2009 and Cutter et al. 2010, encouraging more examples of resilience and how to operationalize this concept.

Data on the indicators were collected using the household questionnaire, which had been developed over many iterations. Many of the indicators used locally relevant proxies, and values attributed, i.e., the greater importance of buffaloes versus goats in measuring livestock resources or different values of landholding in urban versus rural areas, or number of years of education. It is obvious that this system for measuring resilience is not perfect as most of its indicators are the opposite, in spite of efforts to avoid this. It is however the only quantifiable tool for measuring resilience at the community level in the academic or NGO literature of which we are aware in parallel to Twigg's (2010) 170 qualitative characteristics of resilience. It is also obvious that in replicating this method, it should be considered a 'modular skeleton', that can and should be adapted to various situations and for various purposes. It is very important to keep in mind that resilience and vulnerability are relative and context specific, depending on the threat. The 2011 Japanese disaster again illustrated that the Japanese were resilient to the threat of earthquakes of high magnitude, but not to a tsunami of such a large magnitude.

The third objective: to test and improve a participatory methodology for evaluating landslide risk: coping strategies, risk perceptions and causal factors of vulnerability for landslide affected communities; was met relatively late in the research process, after considerable reflection and iteration. Inspiration for a participatory methodologies as for a long time been this researcher's guiding principle, based on writings from Chambers (1989, 2003, 2007, 2009). Gaillard's approaches to participatory mapping (Maceda et al., 2009) and ideas on combining Venn diagrams with social mapping led to the development of the social mapping and participatory risk mapping methods presented in the results sections. These are very qualitative approaches, balancing out the quantitative approach used for measuring resilience, vulnerability and risk. These were very effective for opening dialogue with local communities and learning about land use history and current land use patterns, perception about risk, coping strategies and the importance of community forests for livelihoods and reducing many aspects of risk.

The so-called 'composite vulnerability and risk assessments' were inspired by a perceived lack of such methods for a more holistic approach to assessing risk, besides the quite precise but more narrowly defined geologists approach to assessing landslide risk. Certainly not perfect, our results showed that it was nonetheless possible to develop a risk map based on the definition of vulnerability as composed of economic, social, human, environmental, physical factors, with satisfactory results. This composite risk map resulted in a middle grounds between the geologists risk map and the community participatory risk map.

7.2 Hypotheses

The first hypothesis was: "resilience can be both a process and an outcome that defines the end of a disaster recovery period. It is largely synonymous with coping capacities, or the resources required to return to pre-disaster conditions. ". The conclusion is that there is very little difference between resilience, coping capacities and coping strategies, the latter being more those actions undertaken to deal with every day risks, as well as unusual risks. The difference between and resilience and coping strategies probably only lies in the bouncing back, connotation and choices made after a shock given to resilience, whereas coping strategies does not connote any exceptional shock, but rather choices made on a daily basis. On processes versus outcomes, resilience is both, however the way this study was designed, only outcomes were measured, not processes. This is likely the major shortcoming of the method, as processes such as, 'female empowerment', 'reducing discrimination', 'institutionalization of DRR', are not captured by this study. This is because the method offers snapshots in time of a community's level of resilience, vulnerability, risk and main coping strategies, with the possibility of replicating the study in time in order to monitor relative progress toward risk reduction, or resilience building. It was not designed to capture dynamic processes. Other characteristics of resilience, mentioned by other studies (Moench et al., 2007) to describe resilience such as flexibility/adaptivity, equality, robustness are not explicitly measured, as no useful measures of flexibility were found, but are components of many indicators used by this study.

The second hypothesis was: "Its usefulness is limited to the recovery period for risk management, but it does not necessarily reduce vulnerability or risk. Vulnerability and capacities are more useful terms to describing the long-term process required to address improved livelihood access and resources, which is the most effective way for sustained risk management." According to this research, resilience has a value limited to the recovery and reconstruction phase, not for long term reduction of vulnerability nor as a measure of sustainability, for which vulnerability is more adapted. Thus this method for measuring resilience and vulnerability has value as a decision making tool for better targeting development and/or risk reduction interventions.

The third hypothesis was: "causal factors of resilience are mainly linked to access and rights to sustainable livelihoods resources, namely economic, social, physical, environmental and human/institutional resources."
In retrospect, this hypothesis should be modified to eliminate the word 'sustainable' as the study was not designed to measure sustainability. It did however capture access and rights to resources, especially with regards to community forests and the difference between community forest user groups managed by 'high status' versus 'low status groups'. Based on the case study data, as well as the comparative data analysis and statistical correlations, it was possible to identify the top ten main causal factors of resilience by order of importance:

- Ethnic status (% advantaged population);
- Skills training;
- Economic: employment and remittances;
- Disaster management committee;
- Early warning system, monitoring:
- Community leadership;
- Community Forest User Group;
- Structural hazard protection;
- Health care;
- Access to roads.

For comparison's sake, here are also the top ten vulnerability factors by order of importance:

- Ethnic status (% disadvantaged population);
- Lack of community leadership:
- Poor employment / remittances;
- No/malfunctioning Community Forest User Group;

- Poor forest resources;
- Poor individual and household health status;
- Poor access to roads;
- Poor access to health clinics;
- Poor water quality;
- No hazard protection.

We note that the resilience and vulnerability indicators listed above are to a great extent the flip side of each other and the convergence between the two set of factors is 75%. This result was not intended and not expected, leading us to question whether resilience is at all useful or should just be seen as the positive mirror of vulnerability as claimed by some academics (Cannon, 2008; Klein, et al. 2003). However, in responding to the last hypothesis, "It is possible to measure resilience based on the above identified causal factors", we found that in spite the high convergence, we could have expected a higher negative correlation between resilience and vulnerability factors. This implies that resilience is actually a composite concept behaving differently than vulnerability although there is certainly overlap between the two.

To conclude, we propose this modified SLA to represent the linkages between the vulnerability context, positive or negative access to resources (modified from livelihoods assets) through transforming structures and processes, i.e., institutional processes, market forces, outmigration toward positive or negative livelihood outcomes. This schema (Figure 155) like most models, is an oversimplification of reality but one that summarizes our findings and demonstrates how the factors of resilience, vulnerability, livelihood (or coping strategies) and hazards are linked. Resilience then is a process where access to resources is sufficient to withstand a hazard event, with livelihood strategies that permit a household or community to recover within a 'reasonable' timeframe and resulting in positive livelihood outcomes. When there are insufficient access to resources, and insufficient livelihood strategies, the result is not resilience but increased vulnerability. The amount of resources necessary and type of livelihood strategies will differ depending on the type and magnitude of the hazard.

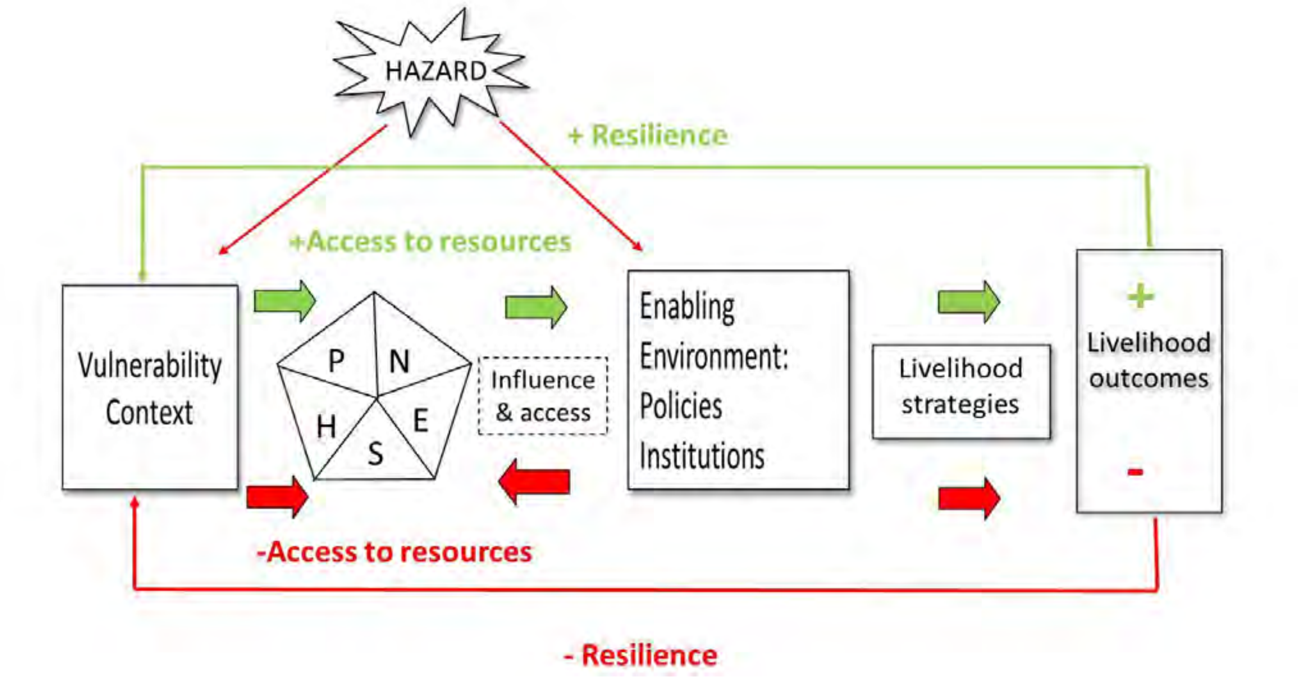


Figure 155. Modified SLA diagram (DFID, 1997), affected by a hazard event (or threat) which modifies the transforming structures and processes and will either lead to positive or negative livelihood outcomes depending on access to resources and livelihood strategies.

7.3 Study limitations and future perspectives

Some of the study's main limitations are listed above: the methodology was mainly outcome-based, a snapshot in time of households' and communities' relative access to resources, a disadvantage of a measurable quantitative methodology. This is therefore not a process-oriented methodology, as it does not take into account the dynamic state of the environmental-social system, nor does it define thresholds at which the system is functioning "normally". However, the advantage of this snapshot approach is that it does offer a methodology for establishing a baseline that can be replicated several years later in order to monitor progress toward established goals for reducing risk, vulnerability or increasing resilience . Another issue that deserves further study is the true cost effectiveness of various interventions for increasing resilience and reducing vulnerability and risk, touched upon in the comparative results section but requiring real life figures for a detailed analysis.

Future research also needs to take better account for participatory aspects of indicator development and data collection on vulnerability and resilience to further reduce an overly "Western" research bias. The vulnerability and resilience indicators that were presented in this study were tested but not designed by community members. To fully achieve participatory research, this aspect needs to be further innovated and tested in future research. Finally, future research would benefit from more direct collaboration with local government officials and NGOs who are working on such issues to get a better "reality check" for needs and improvements to the methodology developed by this research.

Conclusions

8.1 Resilience, the new paradigm?

Because of international recognition of climate change impacts on the world's population, a paradigm shift has occurred over the past decade in the politics of international development, allocation of overseas development assistance and new institutional arrangements. If the 1960s and 1970s were the decades of the 'transfer of technologies' to former colonies, the 1980s and 1990s of the 'sustainable development movement', the new century 2000 has brought with it a notion of 'climate risks' and fear of disasters. The first decade of the 2000s is marked by a sense of urgency and risk, made more relevant to 'developing nations' or Western tourists with the increasing number of climate related 'mega-events', e.g. the 2003 heat wave in Europe, Hurricane Katrina, Hurricane Stan, that occurred this decade. The paradigm of international development politics has thus shifted from sustainable development to increasing resilience to climate risks. This is what Gaillard et al. (2010) calls, 'the politics of the extreme'. Perhaps it was the fatigue with sustainable development, after years of critical assessment by academics, trying to define it, mostly unsuccessfully; or perhaps it was donor fatigue, after decades of unsuccessful efforts to address structural poverty and dwindling natural resources based in poor governance and corruption - that led to the demise of sustainable development to the benefit of the new paradigm: resilience and climate change adaptation.

This paradigm shift could easily be measured through a content analysis of major development policy documents, or informally, by the number of times that resilience was mentioned in sessions at the May 2011 Global Platform for Disaster Risk Reduction, organized by UNISDR[12]. This shift is very visible institutionally as many national development agencies have replaced their natural resources departments by climate change departments. This shift towards resilience, for a researcher of resilience, is certainly interesting although concerning, as there are virtually no guidelines explaining to international donors and national decision-makers what resilience really is, and how to increase it. As the U.N. main agency dealing with disaster risk reduction, UNISDR's main mission is to "increase the resilience of nations and communities to disaster". But what is it they are actually increasing, and what needs to happen in order to increase resilience - provide the world's population with radios? First aid kits? Diverse livelihood opportunities? For a researcher of political science and geopolitics, this shift is certainly interesting and worthy of further research to understand how

[12] During the ISDR Global Platform plenary session on "*Climate change and linkages to DRR*", I heard resilience mentioned 25 times versus 2 for sustainable development.

paradigm shifts take place so quickly, like a new fashion, leading to institutional change and new donor directives (Ayers et al., 2011).

This research is an attempt to fill the perceived gap in guidance on practical methodologies for assessing resilience. It is also an attempt to better define the usefulness and role of resilience as compared to the well tested and familiar notions of vulnerability and risk. To do so, we were fortunate to obtain funding and constitute an interdisciplinary team of researchers to study landslide risk in four different communities of Central and Eastern Nepal using a case study approach. Two case studies on flood affected communities were developed for comparison sake in more urban areas. Methods combined both qualitative participatory approaches to better understand community priorities, risk perceptions, coping strategies and social structures. Detailed geological surveys were conducted to map landslide risk using quantitative geological methods, but also based on local accounts of land use history and identification of land features difficult for foreign eyes to detect, i.e. cracks and scarps. Case study sites were selected in a participatory manner with our host organizations, IUCN and NSCFP, who were extremely helpful in introducing us to communities, which we then selected based on whether the community was faced by risk, representing different types of landslides and different types of communities representing a range of ethnic group affiliations.

What resulted are six case studies, eight different risk maps (geological and composite), three participatory risk maps, two social resource maps, a methodology for quantifying and comparing resilience and vulnerability, an interdisciplinary methodology for assessing risk, numerous scientific posters, articles (Appendix 3), presentations, two completed Master's theses, in addition to this PhD thesis. Certainly improvements can be made to the methodology to make it more cost effective, as each household survey and interview took between one to one half hour. Participatory risk mapping and social resources mapping took a full-day each. Nonetheless, for a small village of 25 households, total time spent was approximately 3 days, after which we reached saturation of information and patience of the community. For larger, more complex villages, one week was the minimum to achieve saturation of information. The best solution was obviously the opportunity to return to the same community during different periods of the year, and at least twice in order to cross validate information received during the previous visit. To conclude, we briefly revisit our main research questions to ensure we answered them all to satisfaction.

8.2 Responding to research questions

Research question 1 - What is resilience of mountain communities to landslides?

This study's definition of resilience, *'the ability of a system, community or household to change in a positive manner, faced with adversity'* closely reflects the UNISDR (2009a) definition *'the ability of a community to resist, withstand and recover and change from a hazard event in a timely and efficient manner'*. The difference is that it allows more flexibility to also take into account other types of adversity that may be more chronic and reoccurring in addition to periodic hazard events. In both cases, chronic and acute stress, resilience does not imply reducing the factors that caused the disaster from occurring, i.e. exposure to a dangerous situation, or vulnerability as caused by many structural factors leading to lack of access to basic resources. This situation is illustrated by a very common situation in Nepal where landless populations settle by rivers or in river banks in very adjustable flexible houses, that are very resilient to flooding, as these houses can easily be rebuilt at low cost. Addressing their resilience does not necessarily address their risk or vulnerability. However, resilience is still a useful term for the specific period during and in the aftermath of a disaster yet the recommendation is not to forgo addressing vulnerability and underlying risk factors.

Research question 2 - Why resilience versus vulnerability and coping strategies?

The second question has basically already been answered by the above statement. Resilience should not become a replacement for sustainable development and the ultimate need to reduce vulnerability and exposure, i.e., risk. Certainly, not all NGOs and local government can address all issues related to vulnerability but addressing only resilience, as defined in this study through capacity building measures, without also tackling underlying risk factors is an unwise and even unethical decision. Therefore one of the main conclusions of this study is that there is not a clear negative correlation between vulnerability and resilience, thus investing in resilience does not necessarily reduce vulnerability. This is most likely because many of the characteristics related to resilience are process related and dynamic (i.e. leadership, mutual assistance) while vulnerability relates to the characteristics of households and communities. Thus the concepts overlap but are not opposites and both need to be addressed to reduce landslide risk.

Another related question is how does resilience differ from coping capacities, coping strategies or adaptive capacities? The conclusion is that there is very little difference between resilience, coping capacities and coping strategies, the latter being more those actions undertaken to deal with every day risks, as well as unusual risks. The difference between resilience and coping strategies is subtle and probably only lies in resilience referring to the recovery process of a system or household. Whereas coping strategies specifically refers to those options and resources that households or communities can access to survive an extreme event or subsistence choices on a daily basis. Adaptive capacities on the other hand, is frequently used by the climate change community in reference to long-term choices made by people in adjusting to new environmental conditions (Burton et al. 1993; Nelson, 2010).

Research question 3 - Is it possible to measure resilience and vulnerability?

The conclusion made by this study is that it is possible to measure resilience and vulnerability, with several caveats: resilience needs to be clearly defined in its scope, context and temporality according to a specific threat; and indicators need to be made context relevant and decided upon by stakeholders. Another question then arises is whether this work demonstrated anything new about the relation between risk, vulnerability and resilience? One contribution for which resilience has the potential to be a useful guide, is for decision-makers to identify gaps in coping capacities for risk reduction alongside vulnerability without replacing it. According to this research, resilience has a value limited to the recovery and reconstruction phase, not for long term reduction of vulnerability nor as a measure of sustainability, for which vulnerability is more adapted. Thus this method for measuring resilience and vulnerability has value as a decision making tool for better targeting development and/or risk reduction interventions.

Research question 4 - What are causal factors of landslide risk for mountain communities in Eastern Nepal?

One of the major findings is that in the Nepal context, ethnicity is a major causal factor of not only vulnerability, resilience but also risk. It was actually the social dominance experienced by the disadvantaged *Thami* indigenous group in Thang thang, Dolakha District, that led to increased risk due to debris flows. This is because of the uncemented irrigation canals crossing steep, landslide-prone terrain, built to irrigate the *Brahmin* 'upper-caste' community’s *khet.* This group dominates local government, the community forest user group, and owns most of the land in Thang thang, for whom the *Thamis* work their fields. Addressing ethnic discrimination is however a structural societal issue, requiring significant effort to remove the ingrained discrimination in place, although a number of local NGOs in government efforts are working in this direction already. Other notable factors were the existence of community leadership, skills training, health clinics, health care, sanitation, savings cooperatives and good water quality. These are so-called 'soft resilience' factors' (Moench et al. 2007) that can be addressed through various government programs and NGO projects as are already underway in many communities across Nepal. Such programs are often very cost-effective with multiplier affects, beneficial not only for the trainees but for their families as well.

What these programs often lack are a focus on landslides and how skills training and community leadership could incorporate landslide risk reduction. Structural or 'hard resilience factors' include measures such as bioengineering, gabion walls, drainage for reducing landslide risk, especially considering the boom in rural road construction. Most of these physical measures can also be very cost-effective and not difficult to put into place with every new road construction, considering the cost of constructing roads in the high cost of repairing destroyed roads. Last but not least, community forests proved to be essential to decreasing risk, vulnerability and increasing resilience, and has over the past two decades become a major factor for providing communities with vital livelihood support, physical protection from landslides but also a social structure through the CFUGs. There are now tens of thousands CFUGS, some better managed than others, but often the only social organization requiring regular meetings in remote communities. The Federation of community forests of Nepal (FECOFUN) is an independent umbrella organization, often organizing skills training in community organization for improving community forests. There is great potential for FECOFUN to incorporate training on landslide mitigation in its regular training sessions, further increasing the importance of CFUGs for reducing landslide risk.

For this researcher, practical experience with resilience was experienced through this PhD thesis and the need to bounce back after multiple shocks, whether difficulties in the field and cancelled visits due to poor weather, academic disagreements, rejected papers or a broken collar bone. To sum up this four-year long thesis process, working as a social scientist in a largely natural science dominated department, at first as the only woman, has certainly been challenging but extremely rewarding and the test of personal resilience. Coming to agreement on definitions of resilience, vulnerability, risk was not easy and the final solution was agreeing not to agree, but rather accepting different viewpoints while maintaining scientific rigor. Resilience is therefore also about having the resources and support to persevere through difficult periods and the reward of research objectives well achieved, invitations to present research findings and papers finally published.

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Appendix I

Household survey questionnaire

Household id: Community: Rural Date of interview:

Coordinates (if any) GPS reading: X: Y: Elevation:

Household information

1.1 Name: ____________________________Age: ______________Occupation:__________

1.2 Household head : M / F

Name of family members (optional)	Relation to hh head	Gender (M/F)	Age	Education	Occupation/ employment/ business
Total:					
Primary completed: PC; Primary incompleted: PI, Secondary completed: SC, Secondary incompleted: SI, University: U					

1.3 Do you have family members who live elsewhere/ abroad?

1.4. Do they send you regular remittances? YES / NO (What percent of your total income?) _______

1.5 Ethnicity: _____________________

1.6 Length of stay in current place: _____________________

1.7 Immigrant: YES/NO

1.8 Previous place: _____________________

1.9. Reason of migration:_____________________

1.9.1 IF DUE TO DISASTER, what disaster and when and where ? _________________________________
(demarcate in map with help of locals …)

2. Physical indicators (mostly based on observations)

# of Floors	Materials used	Age	Height (floors)	Designed (Y/N)	Visible conditions / Observations	Space used for:	Number of rooms

Codes: AD (Adobe), BM (Brick in mud), BC (Brick in cement), RC3 (Reinforced concrete <3stories) , RC4 (Reinforced concrete > 4 stories) , TH (Thatched), ST (Straw)
Conditions: MV - Most Vulnerable V- NV

2.1 Ownership of house: Rented / Owned / Other If rented (rent/month) _____________

2.2 How was it constructed? Single family / two families / many families / paid labor/ Other?

2.3 Do you support your neighbors/relatives to construct houses? YES / NO

3. Household socio-economic status

3.1 Consumer durables

Radio | Cassette player | TV / VCR-Dish
Refrigerator | Washing machine | Sewing machine
Mobile phone | Bicycle | Motor cycle
Car | Other (Specify)

3.2 How much you spend on: (in NRs)

Weddings ____________________ Funerals ____________________
Food (per month) ____________________ Schooling of children _______________
Transportation ____________________ Mobile telephone____________________

3.3 How many months supply of food do you have? (< 3 , 3 – 6, > 6 months)

3.4 Do you have additional income generating activities?

3.5 Number of livestock (actual numbers)

Cow _____________ Buffalo _____________ Goat _____________
Sheep _____________ Hen _____________ Others (specify)

Do your animals graze in forest or stay in pens? _____________________________________

3.6 Seasonal calendar - which crops are grown when?

J	F	M	A	M	J	J	A	S	O	N	D

3.7 Are you able to save money?

3.8 Access to basic facilities to household

SN.	Facility	Accessibility Y/N	Quality Good/ Bad (G/B)	Remarks
1	Water supply			
2	Sanitation/drainage			
3	Telephone			
4	Electricity			
5	Health clinic			
6	School (distance)			
	Others (specify)			

3.9 Energy

Main source of household energy: Wood, LPG, Manure, Electricity, Other (specify)

3.10 Area land owned (unit – Ana / Ropani / Bigah / Kathha) ______________________

3.11 Uses of private land

Subsistence	
Cash crops	
Grazing / fodder	
Natural forest	
Timber production	

3.12 Where is land situated? (mark on map)_____________________ (hill/ adjacent to river)

3.13 Do you have access to community or government forests?
For what purpose?

	Community forest	Govt forest
Grazing		
Firewood		
Fodder		
Timber		
Other NTFP		

3.14 Who decides the rules for the use of the community forest?____________________

3.15 Do you participate in these groups/ decision-making? YES/NO

3.5.1 IF NO, WHY NOT? _________________________

4. Exposure:

4.1 When and how often have you experienced previous disasters?

SN.	Event (what event?) (Date/Year)	Damage loss experienced ? (house, land, persons)	How high was the flood? (landslide?)	Other remarks

4.2 Who decides if you should evacuate your house?________________

4.3 What is the distance to river / stream / landslide slope ? (in meters)

4.4 Who helped you repair / reconstruct your house? ________________________

4.5 Did you borrow money to reconstruct your house? YES / NO

4.5.1 From whom ? (bank, govt, NGO, Local money lenders)

4.6 Have you done anything to prevent the loss from new disasters? YES /NO

If not ? why not ? ____

4.7 Which families do better in your village / neighborhood and why?

4.8 What do you think causes the flooding / landslides?

4.9 What can do you prevent the flood / landslide from damaging your house and land?

4.10 Do you think another flood / landslide will occur and will affect your house?

VERY LIKELY / SOMEWHAT LIKELY / LIKELY / NOT VERY LIKELY / NOT LIKELY AT ALL

4. 11. What do you do when it rains?

5.Institutional, social and health indicators

5.1 Where do you get information about outside events?

Newspapers	
Radio	
Television	
From others in the market/ neighbours	
Government officials	
Other	

5.2 How often do you get information ? daily/ weekly / monthly / annually

5.3 Do you belong to any social organizations?

Community	women groups	cooperatives	
community forest user group	Dhukuti	Green club	Others:

5.5. Who decides over your village / neighborhood?

5.4 Have you had any major illness in family in the past year? YES/ NO ____________

5.4.1 Who is affected (earning member or ??) ____________________

5.4.2. Which illness ?

5.5. Number of visits to clinic or hospitals in last year? ___________________________

5.6 What are your main concerns? (open question)________________________

5 7 What are your concerns on a scale 1 (least) to 5 (most concern)? (read out all options first)

	Scale 1 to 5		Scale 1 to 5
Unemployment		Skills training (adults)	
Flooding		Health and sanitation	
Electricity		Road access	
Earthquakes		Access to land	
Drinking water		Community problems	
Landslides		Education (children)	
Agricultural farming		Other	

5.8 Who helps you if you have some problems?

Family members	relatives	community
Government	Dhukuti	NGOs
Other______________	Bank loans	

5.9 What kind of help you get from them?

6. Is there anything else you would like to add?

6.1 Do you notice any changes in the climate?

6.2 How is this affecting you and your family?

6.3 Have you heard about climate change before? YES /NO

6.4 How do you consider your future ?

6.5 What losses are you willing to accept ?

NAMASTE !!! THANK YOU FOR YOUR TIME!!!

Appendix II

Technical reports

Devkota, S, Jaquet, S, Sudmeier-Rieux, K, , Derron, M-H, Jaboyedoff, M. (2011).*"Preliminary Assessment of Landslides in Dolakha District*", 37p. for local authorities

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Appendix III

I :Peer reviewed articles

Sudmeier-Rieux K, Jaboyedoff M, Breguet A, Dubois J. (2011) "The 2005 Pakistan Earthquake Revisited: Methods for Integrated Landslide Assessment", *Mountain Research and Development*, May, 2011

Sudmeier-Rieux, K, Jaquet, S, Derron, M-H, Jaboyedoff, M, Devkota, S. (accepted (a)) A Case Study of Landslides and Coping Strategies in Two Villages of Central-Eastern Nepal, *Journal of Applied Geography*

Sudmeier-Rieux, K, Jaquet, S, Derron, M-H, Jaboyedoff, M, Basyal, GK. (accepted (b)) A neglected disaster: rural development and landslides in Eastern Nepal's Middle Hills, *Proceedings of the Second World Landslide Forum, Springer-Verlag*

II. Articles/book chapters under development:

Sudmeier-Rieux, K, Gaillard, JC, Sharma S. (accepted (c))"Nepal: Landslides, Flooding and Adaptation Responses" Emerald Books Volume on "Climate Change Modeling for Local Adaptation in the Hindu Kush-Himalayan Region", Edited by Armando Lamadrid and Ilan Kelman, Oslo: Center for International Climate and Environmental Research – Oslo (CICERO)

Appendix IV

Data for figures 151, 152, 153, 154,

Data table - all data											
Sabra		Thang thang		Khariswara		Katahare		Punarbas		Dharan	
Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res
67	72	93	45	90	57	100	42	83	75	100	63
65	74	93	48	68	65	98	43	69	80	95	66
62	77	101	41	70	66	100	41	70	84	91	71
68	71	98	41	74	66	99	42	89	80	95	66
74	66	91	48	70	66	97	44	77	79	105	63
66	73	97	42	78	66	99	43	81	75	91	72
67	72	86	51	78	67	100	46	73	82	99	65
67	72	90	42	73	67	99	41	83	77	92	70
58	81	87	43	73	67	99	40	75	85	102	61
64	72	93	43	62	70	95	43	68	87	94	65
		100	35	62	70	99	43	73	82	88	71
		101	39	76	70	99	42	64	89	91	70
		84	46	76	70	104	41	74	80	95	66
				100	44	107	40	74	78	95	67
						103	42	75	80	96	68
						105	39	101	67	95	68
						106	39	83	76	97	66
						105	37	93	77	90	71
						100	42	81	80	104	61
						102	43	83	74	103	63
						98	42	103	67	95	68
						100	39	80	80	98	66
						100	43	76	75	95	68
						101	40	78	76	99	64
						98	40	87	70	93	70
						106	39	84	73	100	65
						100	38	85	77	97	67
						97	41	80	78	102	62
						94	42	80	74	108	60
						65	73	76	84	101	64
								82	76	103	63
								84	80	97	66
								78	77	98	63
								83	74	93	69
								80	76	97	67
								82	74	100	63
								89	74	101	67
								81	80	102	64
								85	78	96	65
								75	77	102	64
								82	77	97	67
								76	80	101	64
								74	78	91	70
								73	81	89	76
										90	75
										100	69
										89	73
										98	66
										102	66
										102	65
										99	68
										93	70
										96	71
										105	63
										100	66
										92	74
										96	72
										95	72
Averages										102	66
65.8	73.0	93.4	43.4	75.0	65.1	99.2	42.3	80.0	77.8	97.2	67.0

Data table - data without physical data											
Sabra		Thang thang		Khariswara		Katahare		Punarbas		Dharan	
Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res
51	54	74	38	67	50	73	40	71	49	85	41
50	56	72	41	51	55	73	39	58	55	78	44
51	55	79	37	51	56	70	39	58	58	76	48
48	58	75	37	56	56	73	37	68	54	77	43
54	52	71	41	52	56	71	38	65	54	87	40
56	50	73	38	55	56	70	40	68	50	75	50
52	54	71	44	56	57	72	39	60	56	81	40
53	53	70	38	52	57	73	43	70	51	79	45
53	53	71	36	54	57	73	38	62	59	86	38
44	62	75	36	43	63	72	37	56	61	82	40
50	53	79	31	42	60	69	40	60	56	76	46
		80	35	50	63	72	40	52	63	75	47
		68	42	56	60	72	39	61	55	83	41
						77	37	61	53	82	42
						79	36	63	55	80	45
						76	39	80	45	78	46
						78	36	66	54	82	43
						79	36	71	54	76	46
						78	34	63	57	87	38
						73	39	70	49	85	40
						76	41	82	45	78	45
						72	40	66	56	82	43
						74	37	63	50	79	45
						75	41	66	52	84	41
						76	37	69	48	78	47
						74	38	69	48	82	43
						80	37	66	53	80	44
						73	35	62	53	85	40
						70	38	63	51	91	38
						68	40	62	59	83	42
								64	54	86	40
								69	54	80	43
								64	52	81	40
								68	49	76	47
								62	54	80	45
								69	49	83	41
								68	52	84	44
								68	54	85	41
								66	54	79	43
								64	51	84	42
								69	53	80	44
								64	54	84	40
								62	53	76	46
								58	56	74	51
										73	52
										82	46
										75	48
										81	44
										83	44
										84	42
										82	45
										77	47
										77	46
										86	40
										84	41
										73	51
										80	47
										80	47
Averages										87	41
51.1	54.5	73.7	38.0	52.7	57.4	73.7	38.3	65.1	53.2	80.8	43.7

Data table - data without human data											
Sabra		Thang thang		Khariswara		Katahare		Punarbas		Dharan	
Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res	Vul	Res
56	58	82	30	82	52	84	31	67	64	83	48
59	56	82	32	59	54	85	28	60	66	79	52
56	59	89	24	61	54	84	30	61	69	77	53
53	61	89	24	64	57	83	29	73	69	83	48
57	57	80	33	56	55	84	31	61	68	89	47
63	52	88	25	62	57	82	33	65	64	78	53
55	59	75	37	62	56	84	31	61	69	87	49
56	58	81	27	64	58	83	36	67	64	77	53
56	58	78	28	59	58	83	30	60	70	82	49
51	64	85	29	48	62	84	29	56	75	79	49
55	57	92	18	50	62	80	31	61	68	75	53
		92	21	57	62	85	30	54	75	80	51
		75	31	60	61	84	30	60	68	78	51
						87	29	60	67	79	53
						89	29	59	70	81	52
						87	29	81	58	79	52
						90	27	66	66	83	48
						91	27	76	63	80	52
						88	27	64	70	83	50
						85	30	65	63	87	47
						88	30	83	56	81	51
						84	29	68	67	83	49
						85	25	64	63	82	49
						85	31	66	63	82	49
						87	27	74	58	77	54
						85	28	71	61	88	47
						91	25	72	65	85	49
						86	27	67	66	83	49
						80	27	69	61	87	47
						80	29	62	71	86	48
								67	64	84	50
								63	70	84	49
								64	65	84	48
								67	63	79	52
								67	63	82	50
								66	63	82	49
								73	61	84	52
								63	70	87	47
								72	65	84	48
								59	66	86	48
								65	63	85	50
								62	68	85	49
								60	67	79	53
								62	69	75	58
								80	56	80	56
								85	53	85	53
								77	54	77	54
								85	50	85	50
								85	51	85	51
								86	51	86	51
								85	50	85	50
								77	55	77	55
								81	54	81	54
								87	49	87	49
								85	49	85	49
								78	56	78	56
								84	52	84	52
								82	55	82	55
Average								82	54	82	54
56.1	58.1	83.7	27.6	60.3	57.5	85.1	29.2	69.9	62.4	82.2	50.7

Appendix V

Heuristic correlation tests between indicators of resilience and vulnerability.

ENVIRONMENTAL INDICATORS												
RESILIIENCE	VULNERABILITY											
	Poor quality of forest resources	Poor water quality and quantity	Low productivity of soil	Pollution of ground or air	No access rights to natural resources	No erosion protection	No awareness of protection measures	Poor management of land for hazard protection	Poor or no forest management	Poor or no grazing management		
Good management of land and forests	-3	-3	-3	-1	-3	-3	-3	-3	-3	-3	**-28**	
Access and rights to forest products	-3	-3	-3	-1	-3	-3	-3	-3	-3	-3	**-28**	
Good water quality	-3	-3	0	-3	-1	-3	-2	-1	-3	-3	-22	
Good forest quality	-3	-3	-3	-3	-1	-3	-2	-1	-3	-3	-25	
	-12	**-12**	-9	-8	-8	**-12**	-10	-8	**-12**	**-12**	**-26**	**AVE**

ECONOMIC INDICATORS	VULNERABILITY										
RESILIENCE											
	LOW FOOD STOCKS	UNEMPLOYMENT	NO REMITTANCES	INDEBTEDNESS (N/A)	LOW CROP DIVERSITY	POOR ACCESS TO MARKETS	NO HOUSE OWNERSHIP	NO LAND OWNERSHIP	FEW CONSUMER DURABLES	FEW LIVESTOCK	
FOOD STOCKS	-3	-3	-3	-3	-3	-2	-3	-3	-3	-3	-29
INCOME	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-30
REMITTANCES	-3	-3	-3	-3	-1	-1	-3	-3	-3	-3	-26
SAVINGS	-3	-3	-3	-3	-2	-3	-3	-3	-3	-3	-29
CROP DIV	-3	-2	-1	-1	-3	-2	-2	-2	-1	-2	-19
LIVESTOCK	-3	-2	-2	-3	-2	-2	-2	-2	-1	-3	-22
CONSUMER DURABLES	-3	-3	-3	-3	-2	-1	-2	-2	-3	-3	-25
	-21	-19	-18	-19	-16	-14	-18	-18	-17	-20	**-25.7**

SOCIAL INDICATORS										
RESILIENCE	VULNERABILITY									
	No Community leader	No NGO/Govt assistance	No Women's group member	No CFUG membership	No Mutual assistance	No Cooperatives	No Regular meetings	No Extra kinship ties		
Community leader	-3	-3	-3	-3	-2	-3	-3	-1	-21	
NGO/Govt assistance	-3	-3	-3	-3	-2	-3	-3	-1	-21	
Women's group member	-3	-3	-3	-3	-3	-3	-3	-1	-22	
CFUG membership	-3	-3	-3	-3	-3	-3	-3	-1	-22	
Mutual assistance	-1	-1	-3	-3	-3	-2	-2	-1	-16	
Extra kinship ties	-2	-1	-1	-1	-1	-1	-1	-1	-9	
Dis mgmt committee	-3	-3	-3	-3	-3	-2	-3	-1	-21	
EWS	-3	-3	-3	-3	-3	-2	-3	-1	-21	
Evacuation plans	-3	-3	-3	-3	-3	-2	-3	-1	-21	
	-24	-23	**-25**	**-25**	-23	-21	-24	-9	**-19.3**	AVE

HUMAN INDICATORS									
	VULNERABILITY								
RESILIENCE	LOW POP DENSITY	NO EDUCATION	NO SKILLS	NO ACCESS TO INFO	NO KNOWLEDGE OF HAZ	NO ORG SKILLS	POOR HOUSEHOLD STATUS		
HIGH POP DENSITY	-3	-3	-3	-3	-1	-3	-1	-17	
VOCATIONAL SKILLS	-3	-3	-3	-3	-1	-3	-3	-19	
ACCESS TO INFO	-3	-3	-3	-3	-3	-3	**-3**	-21	
KNOWLEDGE OF HAZ	-1	-2	-2	-3	-3	-2	**-1**	-14	
ORG SKILLS	-3	-3	-3	-3	-3	-3	-3	-21	
HOUSEHOLD STATUS	-1	-3	-3	-3	-1	-3	**-3**	-17	
FIRST AID SKILLS	-3	**-3**	-3	**-3**	-1	**-3**	**-3**	-19	
	-17	-20	-20	-21	-13	-20	-17	**-18.2**	AVE

PHYSICAL INDICATORS												
	VULNERABILITY											
RESILIENCE	NO WATER	POOR SANITATION	NO TELEPHONE	NO ELECTRICITY	POOR HEALTH CARE	POOR SCHOOLS	NO ROADS	NO RELIGIOUS ST.	POOR STRUCTURAL PROT	POOR HOUSE STRUCTURES		
EMERGENCY WATER	-3	-3	0	0	-3	0	-2	0	-1	0	-12	
TELEPHONE	0	0	-3	0	-2	0	0	0	-1	0	-6	
ACCESS ROAD	0	0	0	0	-3	0	-3	0	-3	-3	-12	
STRUCTURAL PROT	0	0	0	0	0	0	0	0	-3	-3	-6	
HOUSE STRUCTURE	0	0	0	0	0	0	-2	0	-3	-3	**-8**	
EMERGENCY HEALTH	-3	-3	0	-1	-3	0	-3	0	-3	-2	**-18**	
HELIPAD	0	0	0	0	0	0	0	0	-1	0	-1	
SAFE BUILDING	0	0	0	-2	0	2	-2	-2	-3	-2	-9	
ACCESS TO TOOLS	0	0	0	0	0	0	-2	0	-1	0	-3	
	-6	-6	-3	-3	-11	2	**-14**	-2	-19	-13	**-8.3**	AVE