Summer 8-23-2019

Mountain Livelihoods in a Time of Change: a Case Study of Upper Mustang in Nepal

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MOUNTAIN LIVELIHOODS IN A TIME OF CHANGE: A CASE STUDY OF UPPER MUSTANG IN NEPAL

By

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B.S. Tribhuvan University, Nepal, 2015

A THESIS

Submitted in Partial Fulfillment of the

Requirement for the Degree of

Master of Science

(in Forest Resources)

The Graduate School

The University of Maine

August 2019

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Thesis Advisors: Dr. Sandra De Urioste-Stone, Dr. Parinaz Rahimzadeh-Bajgiran

An Abstract of the Thesis Presented
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Degree of Master of Science
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A case study was conducted in a remote Himalayan village—Yara—in the Upper Mustang region of Nepal. The goal of this study was to understand and assess the livelihood strategies of local people in the village. The study focused on understanding the socio-economic and environmental driving factors of livelihood vulnerability, prevalent livelihood activities, emergent livelihood strategies, and resulting livelihood outcomes in the village. We used multiple data generation methods, which included both qualitative social science and quantitative biophysical components. For the qualitative component, we utilized multiple data generation methods including key informant interviews, semi-structured household interviews, group discussions, and field observations. For the quantitative piece, we employed remote sensing to assess changes in natural resources, including vegetation and snow/ice cover for a 19-year period. We also analyzed climatic parameters to understand the climate pattern in the study area for over 30 years.

Findings from the qualitative research showed the increasing vulnerability of local livelihoods attributed to various factors including changing climate, fragile geology, and degradation of natural resources. Furthermore, other socio-ecological changes have also impacted the livelihoods of locals in the region, including changes in socio-cultural structure and ongoing

migration. Livelihoods in the village have largely focused on subsistence-based activities, and do not properly meet current needs in terms of food and other commodities. As such, locals are increasingly attracted to modern livelihood activities in recent years and rely more heavily on different forms of migration to fulfill those changing needs. Beginning in 1992, with the opening of Upper Mustang to the outside world, local livelihoods have been transformed from living in complete isolation to increasing interaction with the outside world, and hence leading to changing needs and expectations. Moreover, infrastructure development has been changing at a rapid pace in the region in the last decade. With improved accessibility and the increasing impact of modernization, local's connection and interaction with the outside world is quickly evolving, and hence, globalization has become a growing threat to local traditional culture in the region. Additionally, natural resources have degraded in the region attributed primarily to acute water scarcity for drinking and irrigation purposes. Further, the rangelands have degraded over time with a decline in both the quality and quantity of grass every year.

With remote sensing analyses, we studied the historical trend of vegetation in rangelands, which showed a significant decreasing pattern over the last 19 years. Current degradation may be caused by a wide range of variables; climate changes and non-climatic conditions such as the growing stress of livestock on rangelands in the region. NDVI trend analysis provided some helpful information indicating the role of anthropogenic factors. In household interviews, the increasing number of livestock (mainly goats and sheep) also indicated the potential for overgrazing in this region. Changing climatic conditions have further exacerbated the rangeland vulnerability. For example, the decrease of snowfall and its timing alterations have led to changes in the availability of grass in pastures as local people stated. Additionally, the Pearson Correlation analysis showed less interrelation of rainfall with the vegetation growth suggesting that snow plays

a fundamental role in vegetation growth in the rangelands. Snow/ice-covered mountains, the major contributor of water for locals, are melting while resulting in scarcity of water in the region. Moreover, changes in climate patterns (rainfall, temperature, and wind) were observed, with results providing further evidence of the increasing vulnerability of local livelihoods in the region.

In Yara, local people have developed strategies and relied on traditional knowledge that has enabled them to sustain their livelihoods for generations in one of the most challenging and harsh socio-ecological systems on earth. Among adverse environmental, social, economic and, often political circumstances, these communities have developed strategies to cope, adapt and recover from local and global shocks. However, recent and ongoing rapid global changes have threatened the ability of these communities to respond effectively to risks and ensure sustainable livelihoods. The increasing livelihood vulnerability of these communities has highlighted the urgent need to find sustainable and resilient adaptation strategies to overcome growing changes that threaten traditional livelihoods and the ability of communities to cope with change. Further, different households in the area are experiencing livelihood vulnerability at diverse degrees, with poorer households having limited assets to be able to respond to changes and adopt new livelihood strategies. Hence, the gap between those with resources and those with limited assets continues to increase with recent socio-ecological changes, while putting at greater risk the overall livelihoods sustainability in the region. Institutions and processes could play a key role in helping reduce the gap while recognizing different levels of vulnerability and ability to respond to threats to livelihoods.

DEDICATION

I dedicate this thesis to my parents.

ACKNOWLEDGMENTS

First of all, I would like to express my sincere gratitude to my advisors, Dr. Sandra De Urioste-Stone for investing her time and resources to my study, continued support, patience and motivations while reminding me to keep my study and research positive and exciting and Dr. Parinaz Rahimzadeh-Bajgiran for being great mentor with her expertise in remote sensing which helped me to expand my knowledge in this field, and always keeping the door open every time I ran into difficulty or had analytical and writing concerns. Thank you for encouraging me not only to grow as a researcher but also as a human. Over these two years, I've learned a lot from you and from this institution. I was privileged to have you as my advisors, and I must admit that without your guidance and support, this thesis would not have been possible. I am indebted to your efforts and contributions forever.

I would like to thank the members of my thesis committee, Mr. Santosh Sherchan, not only for serving on my committee but also for helping me throughout this research from start to finish; his perspectives into the research region and his prior work experience were very helpful to my research. I appreciate Dr. Christine Beitl for generously providing her time, help and advice in this study.

In Yara, I extend my greatest appreciation to Aama Karsang, Tsering didi, Sonam bahini, and Kalpana bahini for their hospitality and exquisite food during my stay, and to Bhai Wangchuk for his support in carrying out interviews. Many thanks go to Yara village people for allowing me to do this study and patiently responding to my questions. I would also like to thank sir and madam at Yara School for their support during my fieldwork. My gratitude goes to the people in Samzong village for their patience and support in the study which, because of the time constraints, I couldn't

include in this thesis. I also thank teachers in Samzong for helping me in interviews and providing me a place to stay during the fieldwork.

I thank my fellow labmates: Lydia, Brooke, Alyssa, and Jimmy for the thought-provoking discussions, critical feedback, and for all the fun time we had.

Finally, I must express my very profound gratitude to my family: my parents, brother, and sister, who have always been a source of love and support and have encouraged throughout my years of study. Without them, this achievement would not have been possible.

This work was generously supported by USDA Mclntire Stennis Project ME041504.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACA = Annapurna Conservation Area

ACAP = Annapurna Conservation Area Project

CAQDAS = Computer Assisted Data Analysis Software

CARE = Cooperative for Assistance and Relief Everywhere

DFID = Department of International Development

EU = European Union

HDI = Human Development Index

ICIMOD = International Centre for Integrated Mountain Development

IDW = Inverse Distance Weighted

IRB = Institutional Review Board

LAPA = Local Adaptation Plan of Action

M a.s.l. = Meter above sea level

NAPA = National Adaptation Plan of Action

NDSI = Normalized Difference Snow Index

NDVI = Normalized Difference Vegetation Index

Oxfam = Oxford Committee for Famine

UNDP = United Nations Development Programme

UNFCCC = United Nations Framework Convention on Climate Change

WHO = World Health Organization

CHAPTER 1: INTRODUCTION

1.1 Problem Statement and Rationale

The Himalaya or Himalayas (हिमालय) – the highest mountain range in the world, extends over 2,500 km east to west through Nepal and four other countries in Asia (Figure 1.1): Bhutan, China, India and Pakistan (Le Fort, 1975). These mountains referred to as "The Third Pole" are the source of Asia's major river system (Wester et al., 2019). The region is considered one of the global biodiversity hotspots and is home to a large diversity of life types attributed to its physical setting and varied climatic characteristics (Myers et al., 2000; Chettri et al., 2008).

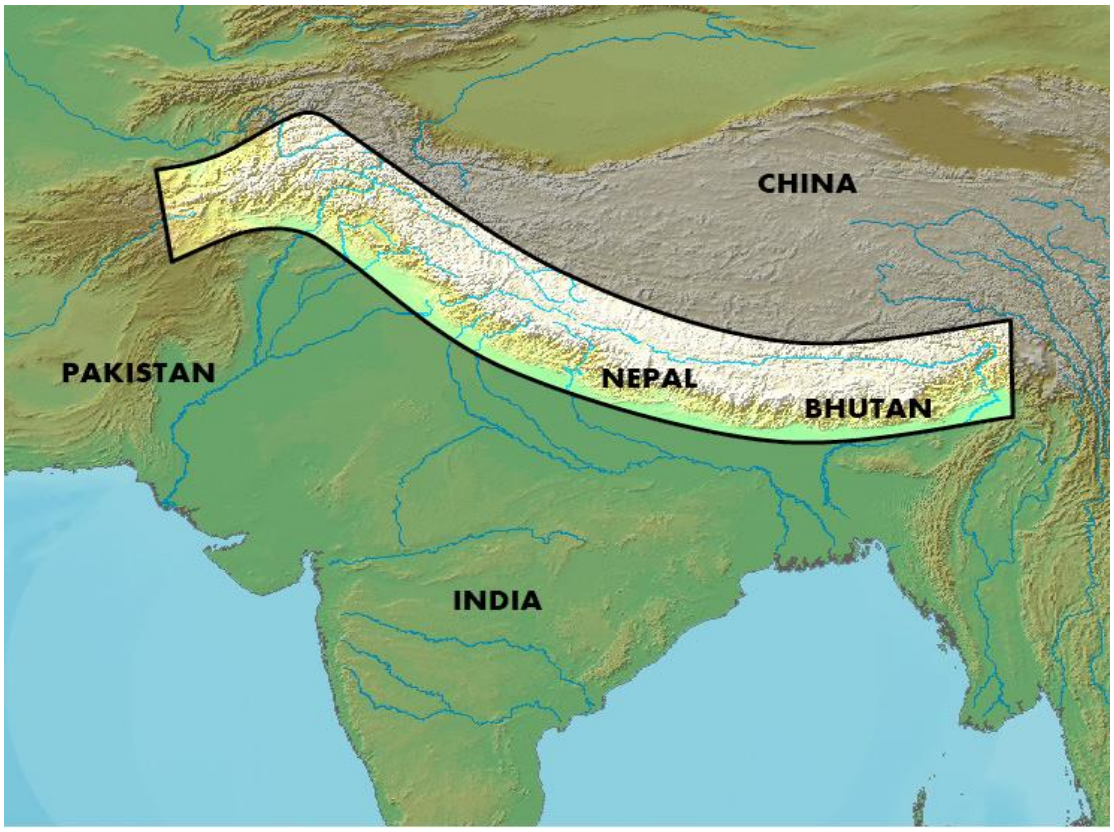


Figure 1.1. Location of the Himalayas along with five countries in Asia (Source: http://www.himalaya-foto.ru/himalayas-map.htm) (Map is not in scale)

The biodiversity and physical components of this region provide a wide range of ecosystem services such as recreation, water, spirituality, and energy among others (Figure 1.2), and serve as

livelihood basis for millions of people living in the region (Hamilton, 2002; Körner, 2004; Viviroli & Weingartner, 2004). About 10% of the world's population resides in this region and are highly dependent on the area's natural resources for their livelihood and wellbeing; an estimated 40% of the population living in the downstream region depend on water and forest resources, biodiversity and niche products, hydroelectricity, mineral resources, outdoor recreation opportunities accompanied by fascinating cultural and spiritual heritage (Schild, 2008).

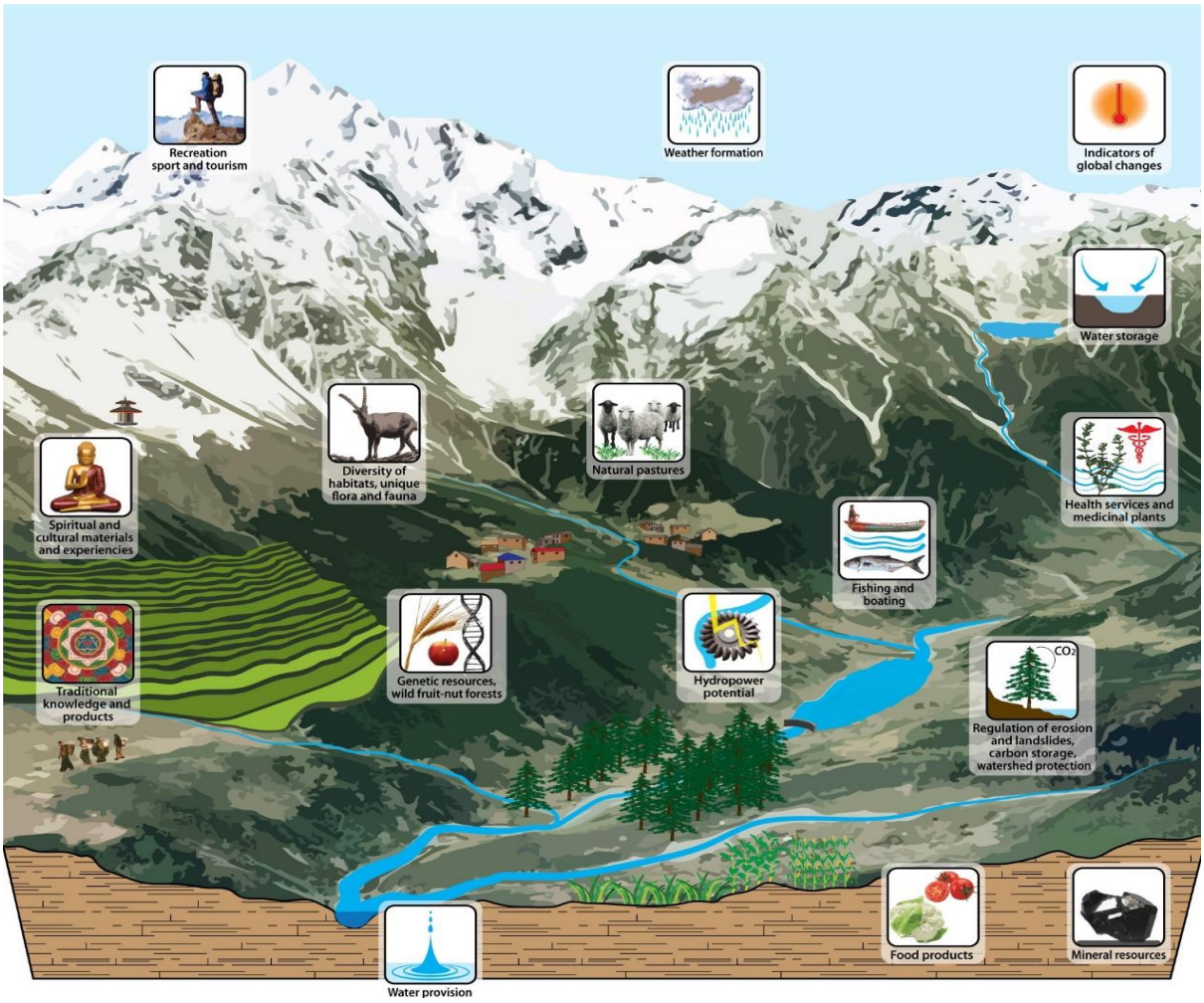


Figure 1.2 Mountain ecosystem goods and services (Source: https://www.grida.no/resources/12619)

Characterized by its rugged topography and remoteness, the Himalayas are well known for their unique cultural identity and diversity. For centuries, people in the region have developed

unique livelihoods, weaving nature and culture in the same living environment. However, being the youngest mountain range in the world (Valdiya, 1998), the Himalayas are geologically fragile and vulnerable to erosion, landslides even without human interferences (Wester et al., 2019). As a result, people's livelihoods, particularly those of the most remote areas of the Himalayas, are built upon harsh conditions including adverse environmental, social, economic, and, often political situations (Mishra & Chaudhuri, 2015). Despite these challenging circumstances, people from mountain communities have adjusted their livelihoods to sustain in such environment by fulfilling their needs with what nature has provided (Shrestha et al., 2015). Over many generations, mountain communities in the Himalayas have demonstrated diverse forms of resilience and adaptation capabilities that have been an integral part of their culture (Schild, 2008; Wu et al., 2014; Gautam & Andersen, 2016; Gentle & Thwaites, 2016). Moreover, the traditional ecological knowledge (TEK) and practices have played a fundamental part in coping with and adapting to difficult mountain environments (Byg & Salick, 2009; Chaudhary et al., 2011; Berkes et al., 2016).

In recent years, the Himalayan region has undergone rapid global changes driven by various forces such as climate change (Shrestha et al., 1999; Fujita et al., 2006; Eriksson et al., 2007; Baidya et al., 2008; Xu et al., 2009; Bajracharya & Mool, 2009; Shrestha & Aryal, 2011; Wester et al., 2019), land use/land cover change (Awasthiet al., 2002; Semwal et al., 2004), natural disasters (Petley et al., 2007; KC, 2013; Fort, 2015), globalization (Jodha, 2000; 2005), exploitation and depletion of natural resources (Ali & Benjaminsen, 2004; Rasul, 2014), infrastructure development (Sharma & Awal, 2013; Molden et al .,2014; Butler & Rest, 2017; Sudmeier-Rieux et al., 2019), migration (Ikeda & Ono, 2004; Adhikari & Hobley, 2015; Tiwari & Joshi, 2015) , urbanization (Goodall, 2004; Morcom, 2015), tourism development (Ives, 2004; Nepal, 2005; Nyaupane & Chhetri, 2009), and socio-economic changes and cultural

transformation (Becken et al., 2013; Devkota, 2013). Climate change impacts in mountain regions have been prominent, including variation in rainfall and snowfall, drought, glacier melting and glacial lake outburst, floods, and landslides; these changes have led to crop failures, water scarcity as well as increasing livelihood and food insecurity (Gentle & Maraseni, 2012; Macchi, 2011; Pandey & Bardsley, 2015). Moreover, mountain regions have been recognized as "climate change hotspots" with serious consequences for mountain ecosystems and downstream regions (Macchi, 2011; Gentle & Thwaites, 2016). Similarly, mountain regions are increasingly exposed to rapid and often unplanned infrastructure development leading to greater exposure to markets beyond its mountainous perimeter (Bishop, 1990; Rahimzadeh, 2016). Consequently, though local people might rejoice from the arrival of modern conveniences such as roads, electricity, and communication, it is a great concern that the old traditional livelihoods and cultures possibly are at risk due to the exposure to new ways of lives and availability of new commodities (http://www.vcproject.org/projects/past/).

In response to such rapid global changes, countries in the Himalayan region have started implementing adaptation plans at national and local levels. To facilitate adaptation processes, the United Nations Framework Convention on Climate Change (UNFCCC) established the National Adaptation Program of Action (NAPA) in 2001, which aimed to address the most urgent adaptation needs of the Least Developed Countries (LDC) including countries in the Himalayan region (Mainlay & Tan, 2012). The Government of Nepal initiated the NAPA process in May 2009 and completed it in September 2010 (Government of Nepal, 2010). NAPA in Nepal mainly focused on six thematic areas; agriculture and food security, forests and biodiversity, public health, water resources and energy, human settlement, and climate-induced disaster (Government of Nepal, 2010). NAPA was prepared to address the vulnerability and the adverse impacts of climate

change on the six thematic areas. Further, NAPA aimed at providing a basis for the development of adaptation strategies while prioritizing the adaptation needs (Government of Nepal, 2010). The plan aimed to reduce vulnerability and build community resilience by diversifying livelihood strategies. To further support the implementation of NAPA, the Government of Nepal with the financial support from Department for International Development (DFID) and European Union (EU) initiated the development of Local Adaptation Plan of Action (LAPA) in 2011. The LAPA framework was aimed at making adaptation planning a bottom-up, participatory and flexible process that would identify the most vulnerable people and allow them to make informed decisions on priority adaptation actions (Watts, 2012).

There has been a continuous effort in the development and implementation of adaptation plans through governmental and non-governmental organizations in Nepal (MoFE, 2018). However, the current understanding of adaptation needs and mountain-specific interventions are still very limited due to the insufficient knowledge of global change impacts on mountain peoples and ecosystems (Beniston, 2003; Füssel, 2007; Bellard et al., 2012; Mishra et al., 2019). Further, there are still major gaps between the policy objectives and the actual implementation of adaptation programs. Therefore, the incrementing evidence of the many vulnerabilities of mountain communities has highlighted the urgent need to find ways to support livelihoods, focusing on sustaining mountain environments at regional, national and international scales (Bellard et al., 2012; Gioli et al., 2019; Wester et al., 2019). Moreover, the adaptation needs of such highly vulnerable communities deserve special understanding and targeted action (Mishra et al., 2019).

Thus, this study focuses on understanding (1) the biophysical and social changes impacting the residents in Upper Mustang region of Nepal—known as the last forbidden kingdom (Shackley, 1994; Peissel, 1998; Gurung & DeCoursey, 2000; Craig, 2004; Wright, 2015), (2) the past and

current livelihood strategies pursued by these residents that have resulted from changing conditions, and (3) the results of changes in livelihood strategies. Moreover, this study explores the environmental and socio-economic factors that lead to livelihood vulnerability, seeks to identify the livelihood strategies practiced by local people, institutional arrangements that determine the sustainability of rural livelihoods, and resulting livelihood outcomes.

1.2 Overall Research Goal

The overall goal of this study is to understand and assess the livelihoods of local people in Yara village through environmental and socio-economic assessment approaches.

1.2.1 Research Objectives (R.O.) and Research Questions (R.Q.)

R.O.1: To gain an in-depth understanding of mountain people's perceptions of factors that lead to livelihood vulnerability and adaptation strategies in place to increase the sustainability of rural livelihoods in the region.

- **R.Q.1** What are the drivers of change that have influenced livelihoods?
- **R.Q.2** What, if at all, do participants perceive as the changes in climate over the last 30 years?
- **R.Q.3** What do participants describe as the livelihood adaptation strategies (current/past/future), and to what drivers of changes do they respond?
- **R.Q.4** What are the facilitators and barriers to adopting new livelihood strategies that may help adapt to changing conditions?

R.O.2: To assess the trend in vegetation, permanent snow/ice cover, and their relationships with climatic parameters and anthropogenic impacts.

- **R.Q.1.** What are the changes in climate variables over a 30-year period based on meteorological data records?
- **R.Q.2**. How have the vegetation (growing season maximum NDVI) and permanent snow/ice cover changed over 20 - 30 year period based on remote sensing analyses?
- **R.Q.3.** What kind of relationship is there between vegetation (growing season maximum NDVI) and rainfall?
- **R.Q.4.** What kind of impact do the anthropogenic activities have on vegetation (growing season maximum NDVI) and rainfall?

1.3 Structure of the Thesis

This thesis is organized into six chapters. Chapter one presents the conceptual underpinnings for the study while describing various component of the sustainable livelihoods framework.

Chapter two presents the methodological approach and multiple qualitative data generation methods used in this study. The chapter describes the research paradigm that shaped this study, the role of the author as a researcher-as-instrument, the ethical issues considered in this study, and how the trustworthiness was addressed in the research process and outputs, are discussed.

Chapter three presents a rich description of the context of the case study from the national to the sub-regional contexts. This in-depth description would help readers better understand the contextual factors that determine/frame the case.

Chapter four incorporates a description of the Yara case study local context. It provides a deep description of key patterns that emerged from the qualitative data analysis of participants' meanings of change, livelihood vulnerability and adaptation strategies to support sustainable rural

livelihoods. Categories reflect the sustainable rural livelihoods framework (Scoones, 1998; DFID, 1999).

Chapter five presents the methodological processes used to analyze changes in vegetation and permanent snow/ice cover. It discusses the results from the remote sensing and climate data analyses.

Finally, chapter six synthesizes key findings from the triangulation of the multiple research methods, recommendations on how to enhance the sustainability of rural livelihoods, future research to be conducted based on the results from this study.

1.4 Livelihoods and Sustainable Rural Livelihoods Framework

The concept of “livelihoods” emerged in the mid-1990s and continues to evolve as researchers and practitioners apply the concept to advance our understanding and support of rural development, environmental management, and poverty reduction (Chambers & Conway, 1992; Thomas-Slayter & Bhatt, 1994; Scoones, 1998, 2009; Ellis, 2000; Barrett et al., 2001; Gautam & Andersen, 2016; Zhang et al.,2019). Although the term livelihood seems simple, its meaning is elusive, both because it is vaguely defined and because it is used differently by multiple scholars (Carswell, 1997; Ellis, 2000). Livelihood is variously characterized as, “making a living", "securing necessities of life”, and “sustaining a family" (UNDP, 2010). Despite the existence of competing definitions, the term is widely understood as the development and implementation of strategies for human survival (UNDP, 2010). The livelihood definition provided by Chambers and Conway (1992) has been widely accepted in development studies, and is extensively used by several key scholars such as Ellis (2000); Hussein & Nelson (1998); Scoones (1998); and Carswell (1997):

> *"A livelihood comprises the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living: a livelihood is sustainable which is capable to cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide the next generation with sustainable livelihoods; and which offers net livelihood benefits at local and global levels and in short and long-terms." (Chambers & Conway, 1992, p.7)*

The essence of a "livelihood" has been expressed as a relationship between different components for making a living and has been studied by various researchers (Scoones, 1998; Carney, 1998; Drinkwater & Rusinow, 1999; Neefjes, 2000) through the conception of the sustainable rural livelihoods framework (Norton & Foster, 2001). Various development organizations such as Cooperative for Assistance and Relief Everywhere (CARE), Oxford Committee for Famine (Oxfam), United Nations Development Programme (UNDP), and UK Department for International Development (DFID) have adopted and promoted the sustainable rural livelihoods framework as a basis for their development programs and practices. The framework focuses on how sustainable livelihoods in different contexts are achieved by using various available resources, drawing on different livelihood strategies, and the facilitators and barriers to the attainment of sustainable livelihoods (Carney, 1998; DFID, 1999; Scoones, 2009). This framework was developed with rural contexts in mind, and the need to respond to the specific threats and limited capitals available to these normally sensitive communities (Solesbury, 2005). The framework considers livelihoods as a system and provides a way of understanding the assets of people, the environment or context in which the livelihoods are developed, the factors that make livelihoods sensitive or vulnerable to shocks and stress, and the strategies developed to overcome such shocks to improve and enhance sustainable livelihoods (Ellis, 2000; Solesbury, 2005).

We have adopted the livelihoods framework developed by the DFID (1999) as shown in Figure 1.3 for analytical purposes. The framework we used was designed to study and develop programs to improve rural livelihoods, particularly in developing countries. The framework is

holistic in nature and puts people at the center of development. It recognizes the dynamic nature of livelihoods and identifies that there is a wide range of forces that influence and shape livelihood strategies and outcomes (Kollmair & Gamper, 2002).

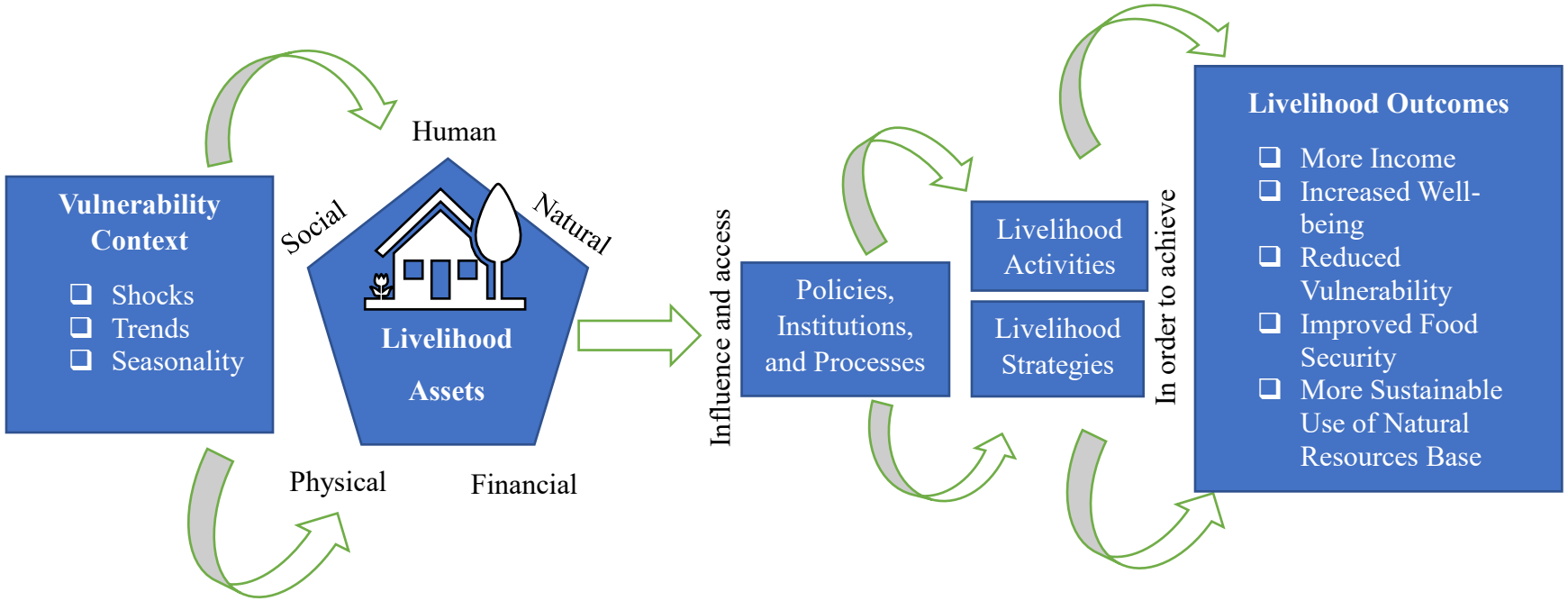


Figure 1.3. Sustainable Rural Livelihoods Framework (Adapted from DFID, 1999)

1.4.1 Components of the Sustainable Rural Livelihoods Framework

The sustainable rural livelihoods framework seeks to present primary factors that affect people's livelihoods, their significance, and the nature of interactions (DFID, 1999). The framework essentially comprises the following key components: (1) livelihood assets, (2) vulnerability, (3) transforming structures and processes, (4) livelihood activities and strategies, and (5) livelihood outcomes (Figure 1.3). These are described below.

1.4.1.1 Livelihood Assets

The framework highlights the relevance of assets owned and controlled by the households. Assets also referred to as capitals, are the basic building blocks that the community and households derive their livelihoods from. Assets are capital stocks that can be utilized directly or indirectly to generate the household's means of livelihood (Ellis, 2000). Various authors (Maxwell & Smith, 1992; Reardon & Vosti, 1995; Moser, 1998) have identified and categorized assets to capture the important distinctions between different types of capital. The DFID framework (Figure 1.3) contains five asset categories: human, social, natural, physical, and financial capital (see also Carney, 1998; Scoones, 1998).

Human capital refers to education, skills, labor capacity, and health, all of which can support or enhance the development and implementation of different livelihood strategies (Carney, 1998; Ellis, 2000). Human capital, as an intrinsic value, plays a crucial role while capitalizing on any of the four other types of capital (DFID, 1999).

Social capital includes the social resources from which people derive their livelihoods (Scoones, 1998), such as networks in society, relationships, trust and reciprocity, norms and common rules, networks, and groups (DFID, 1999; Scoones, 1998). Trust, reciprocity, and networks in individual and society facilitate cooperation. Similarly, networks and groups increase

people's trust and help expand their connection and access to wider institutions, such as governmental and non-governmental organizations (DFID, 1999). Further, norms and rules bring mutual understanding and agreements in society.

Natural capital refers to the natural resources and ecosystem function from which products and livelihood services are derived (Ellis, 2000; DFID, 1999). Natural capital consists of various public resources that can be tangible or intangible (like atmosphere, clean air), and are used straight for production, for example, land, water, forests, etc. Groot, Wilson, & Boumans (2002) categorized such ecosystem functions derived from natural resources into four categories: regulation functions that regulate ecological processes and life support systems through biospheric processes and other biochemical cycles; habitat functions that provide shelter and reproduction habitat to wild plants and animals; production functions that provide goods for human consumption such as food, raw materials, and energy resources; and information functions that provides aesthetic, cultural and spiritual inspirations, recreation opportunities, and cognitive development.

Physical capital includes the basic infrastructure and producer goods necessary to sustain livelihoods. The infrastructure consists of physical structures such as buildings, roads, water supplies and electricity that help people to meet basic needs. Producer goods are tools and techniques that people use to function more productively such as technology, communications, equipment and raw materials (DFID, 1999).

Financial capital comprises the financial resources available or equivalent financial resources that enable people to afford and adopt different livelihood strategies (DFID, 1999). This form of capital consists mainly of cash, savings, access to credit in the form of a loan and liquid goods like livestock and jewelry (Ellis, 2000; DFID, 1999). Financial capital is likely the most diverse amongst the five categories of assets since it can be turned into other types of capital or

used for direct achievement of livelihood outcomes (e.g. buying of food to minimize food insecurity) (Kollmair & Gamper, 2002).

1.4.1.2 Vulnerability

The concept of vulnerability has been applied in various fields of research to address multiple topic areas and stressors, such as natural hazards (Hofflinger, 2017; Fang et al., 2018), rural livelihoods (Lin & Chang, 2013; Ellis, 2000; Dercon & Krishnan, 2000), food security (Douxchamps et al., 2016), poverty reduction (Moser, 1998; Eriksen & O'Brien, 2007), disaster risk management (Yodmani, 2001; Ezell, 2007), public health (Galea et al., 2005; Haines et al., 2006), global environmental change (Bennett et al., 2016; Cutter, 1996), and climate studies (Gallopín, 2006; Pandey & Bardsley, 2015). While various research approaches to study vulnerability exist, different definitions are present and there is no consensus on its meaning (Adger, 2006). As a result, vulnerability interpretations are found to be highly dependent on context and disciplinary perspective. Though different approaches have been developed within diverse disciplines, the main notion of vulnerability is the risk of damage or harm (Liverman, 2001).

Vulnerability is primarily described as the interaction of various parameters i.e., exposure and sensitivity to stresses, and adaptive capacity (Adger, 2006; J. McCarthy & Canziani, 2002). Exposure relates to nature and degree to which a system (e.g. community) is exposed to climatic and non-climatic variations and sensitivity addresses the degree to which a system is affected, either adversely or beneficially, by climate or non-climatic stimuli. However, exposure and sensitivity are closely linked and are nearly inseparable. They are determined by the interaction of a system's environmental and social features (e.g. location of settlements, geography, livelihoods,

land use, social network, etc.) (Smit & Wandel, 2006). Adaptive capacity is defined as the ability of a system to adjust to such climate variability and other extremes (Adger et al., 2003). Adaptation and adaptive capacity will be discussed in detail later in this chapter.

From a livelihoods perspective, vulnerability is the result of households' exposure to livelihood stresses caused by both climatic and non-climatic conditions (e.g. geological processes; earthquake, population growth, migration, pollution, land-use changes, land degradation, institutional changes, diseases etc.) and their inadequate ability to cope with, recover or maintain their household and community well-being (Adger, 1999). In the rural context, the livelihoods of community residents are completely dependent on natural resources (Ellis, 2000; Adger, 2006). Human actions shape their environment and in turn, the environment plays a major role in shaping the socio-economic system (Renaud, 2006; Warner, 2010). While assessing the vulnerability of communities, the environmental sphere cannot be separated from the socio-economic sphere because of their interconnectedness. Therefore, in the context of rural livelihoods, vulnerability of communities to natural and anthropogenic hazards should be approached from a multidimensional perspective, which includes environmental, social and economic spheres while incorporating features such as exposure, sensitivity and adaptive capacity (Renaud, 2006).

One framework that has been proposed to study vulnerability from a multidimensional perspective is the sustainable rural livelihood framework (Ellis, 2000). It considers vulnerabilities as a fundamental part of the context while putting livelihoods at the center of the framework. Moreover, the sustainable rural livelihoods framework considers vulnerability as part of the context in which livelihoods are shaped (Twigg, 2001). Within the sustainable rural livelihoods framework, vulnerability refers to the external factors for which people have little or no control. These factors include shocks (natural, economic conditions, health, crop/livestock health,

conflict), trends (increase/decrease in population, decline in natural resources, increase in price, evolution of technology, human development etc.) and seasonality (fluctuation in prices, change in production, health conditions, employment opportunities, etc.), which affect people's assets and the possibilities open to them in pursuing beneficial livelihoods (DFID, 1999).

Different components of vulnerability affect people in different ways (DFID, 1999). Natural shocks, for example, can have more adverse impacts on agriculture than on employment. Thus, understanding the nature of the vulnerability is crucial in sustainable livelihoods analysis.

1.4.1.3 Transforming Structures and Processes

Transforming Structures and Processes represent the institutions, organizations, policies, and legislation that shape livelihoods (DFID, 1999). They occupy a central position in the framework and directly feedback the vulnerability context. They operate at all levels, being the center of importance and effectively determining access to various types of capital, livelihood strategies, decision making bodies and sources. They also regulate the terms of exchange between different types of capital and various forms of outcomes from livelihood strategies.

Structures are the hardware – public as well as private- that lays down and implements policy and law, provides services, purchases, trades and performs all kinds of other functions that affect livelihoods (DFID, 1999). Structures exist at various levels in government organizations and operate in cascading levels with varying degrees of autonomy and scope of authority. Similarly, private and non-governmental organizations also operate at different levels from the multi-national level to the local region at the lowest level. Structures are important because they are the bodies that make processes function at different levels. An absence of appropriate structure can, therefore, be a major constraint to the development process. This is a particular issue in rural remote regions

as many important organizations (both public and private) do not reach these areas. In the absence of well-working structures, people often do not get even the basic services, the market is out of reach and overall vulnerability increases (Scoones, 1998; DFID, 1999).

Processes are described as the software that determines the way in which structures and individuals operate and interact to derive livelihoods (DFID, 1999). These processes are crucial as they operate at various levels of structures and sometimes there are overlaps, which makes the processes complex and conflict may arise. Important transforming processes to livelihoods comprise policies, legislation, institution, culture, and power relations (DFID, 1999). Processes are the incentives for people to make livelihood choices while providing access to assets.

1.4.1.4 Livelihood Activities and Strategies

Through the use of available assets, people practice various livelihood activities. In the rural context, livelihood activities typically consist of agriculture, livestock rearing, tourism, labor work, etc. In developing livelihood activities, social factors and exogenous trends and shocks mediate and affect how activities are adopted and maintained, and the portfolio of livelihood strategies pursued and modified (Ellis, 2000).

Livelihood strategies are tactics developed and adopted that allow people and communities to cope, adapt, and recover from shocks or adverse environmental, social, economic, and often political circumstances (Scoones, 1998; Ellis, 2000; Barrett et al., 2001). Scoones (1998) described three types of livelihood strategies- agricultural intensification and extensification, livelihood diversification, and migration. Agricultural intensification and extensification can be considered as common livelihood strategies used in rural communities, whereby intensification is the process of improving agricultural technology that is mostly facilitated by institutions and organizations,

whereas extensification focuses on expanding the use of resources in a given land or by cultivating new land (Scoones, 1998). Similarly, livelihood diversification refers to diversifying income-generating activities towards off-farm activities or having communities rely on more than one economic activity (Scoones, 1998). The final approach is migration, which refers to relocation or human movement, and reliance on remittances as a source of income (Scoones, 1998).

1.4.1.5 Livelihood Outcomes

The final component of the framework (Figure 1.3) is the livelihood outcomes; these are the products and structural changes resulting from livelihood strategies. Outcomes include things like improved food security, higher income, greater well-being, reduced vulnerability, and improved environmental sustainability (DFID, 1999).

In general, the sustainable rural livelihoods framework offers an analytic basis for understanding the complexity of livelihoods (Ellis, 2000). Livelihood strategies, however, are often context-specific; hence, strategies will vary based on the specific and unique socio-ecological characteristics of locations and the availability of resources and opportunities. Therefore, it is crucial to formulate policies and development programs with a thorough understanding of the context—available assets/capitals, prices that mediate the level of access and ability to use those assets, in order to support livelihood strategies.

1.5 Adaptation

The term adaptation has been widely used in both social and biophysical sciences. The concept comes from natural sciences, particularly from evolutionary biology (Adger, 1999; Moser & Ekstrom, 2010). It broadly refers to the processes by which animal or plant species fit into the changing environment in various ways; by modifying and developing its structure, physiology,

genetics, and reproduction as well as in other characteristics (Dobzhansky, 1970; Winterhalder, 1980).

Recently, there has been a growing focus on utilizing and defining adaptation across multiple disciplines, with extensive research and conceptual development. As such, various definitions have been proposed, mostly addressing how natural and human systems adjust or change in order to respond to external stressors (Davies & Hossain, 1997; Smit et al., 2001; Berkhout et al., 2006; Nelson et al., 2007; Reed et al., 2013).

In the social context, adaptation refers to the adjustment process in a system (individual, household, group, community, region, and country) to cope with and adjust to change, stress, risk, or hazard (Smit & Wandel, 2006). Within the context of climate change, the International Panel on Climate Change (IPCC) defines adaptation as "adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities."

It is, however, becoming increasingly apparent that adaptation processes in practice refer not just to climate change alone, but can either be initiated or implemented in non-climate ways, for example with socio-economic changes, political changes and other environmental stressors (Moser & Ekstrom, 2010). Further, in the literature on livelihoods, adaptation is defined as the continuous process of changes to livelihoods that either improve existing security and wealth or try to reduce vulnerability and poverty (Davies & Bennett, 2007). Moser & Ekstrom (2010) define adaptation as:

> *"Adaptation involves changes in socio-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes." p.26*

Adaptation can be anticipatory or reactive based on its time applied and can be autonomous or planned depending on its degree of spontaneity (Smit et al., 2000). It can, therefore, lead to a range of results while fulfilling short to long-term strategies. However, not all adaptation strategies can reduce harm or take advantage of beneficial opportunities (Moser & Ekstrom, 2010). This is further described by categorizing adaptation as positive and negative by Davies & Hossain (1997). Adaptation is positive if it is implemented by choice, can reverse and reduce risk, including the diversification of existing livelihoods. Usually, positive adaptation leads to increased security and wealth. Negative adaptation is out of necessity, is irreversible, and often does not help to reduce vulnerability on a permanent basis. Adaptation is primarily focused on producing positive results in adversity; however, adaptation strategies may sometimes be contrary to our expected results. As such, negative adaptation occurs, which is mostly due to poor people's inability to adapt their livelihoods and cope with short-term shocks given limited assets (Davies & Hossain, 1997).

1.6 Adaptive Capacity

Adaptive capacity is the ability of a system to adapt to changes and disturbances. Adaptation depends on adaptive capacity that defines the ability of a system to deal with exposures and sensitivities, which in turn reduces vulnerability (Smit & Wandel, 2006). Plummer and Armitage (2010) define adaptive capacity as,

> *The capacity of a social-ecological system to be robust to disturbance, and to adapt to actual or anticipated changes (whether exogenous or endogenous). From a social systems vantage point, adaptive capacity is determined by the suite of resources (technical, financial, social, institutional, political) held, and the social processes and structures through which they are employed and mediated (i.e., governance)* (p.6).

In the social sciences, adaptive capacity not only refers to adaptation, but to the capability of humans and the entire community to learn, experiment and create innovative solutions in order to maintain sustainable livelihoods in complex socio-ecological systems over time (Smit &

Wandel, 2006; Carpenter & Brock, 2008; Plummer & Armitage, 2010). As described in the previous section on vulnerability, adaptive capacity plays an important role in reducing vulnerability to multiple stresses while moderating exposure and sensitivity (Adger et al., 2003).

Adaptive capacity depends on the context and varies between different levels (Smit & Wandel, 2006). For example, the adaptive capacity of one country may be completely different (high or low) compared to other countries, which may go down further to a smaller level, such as to the community, from social groups to individuals over time. Furthermore, Smit and Wandel (2006) suggested there are various factors known as determinants of adaptive capacity such as, managerial ability, access to financial, technological and information resources, infrastructure, the institutional environment within which adaptation occurs, political influence, kinship networks, etc. These determinants also function differently varying from the local level to more broad socio-economic and political systems (Smit & Wandel, 2006). However, Smit and Wandel (2006) further argued that adaptive capacity determinants are not mutually independent. For example, economic resources can make new technology easier to implement and make opportunities accessible. Likewise, strong kinship networks can increase adaptive capacity through increased access to economic resources, increased management capacity, and manpower, and psychological stress buffering.

CHAPTER 2: RESEARCH METHODOLOGY

2.1 Research Paradigm

Livelihood is a complex and dynamic phenomenon (Chambers & Conway, 1992; Ellis, 2000; Haan, 2000), influenced by multiple factors, is context-specific, and it is subjective to communities and people within it (Hussein & Nelson, 1998; Kaag, 2004). The in-depth study of the complexity of livelihood requires the participation of people (Emic perspective) and cannot be thoroughly explored from using an outsiders viewpoint (Etic perspective) (Hancock & Algozzine, 2016; Creswell & Poth, 2018). Therefore, active involvement of individuals is crucial, as it is the view of individuals who live within a given context which gives relevant insight into their lived experiences (Merriam, 2009; Patton, 2015; Silverman, 2016).

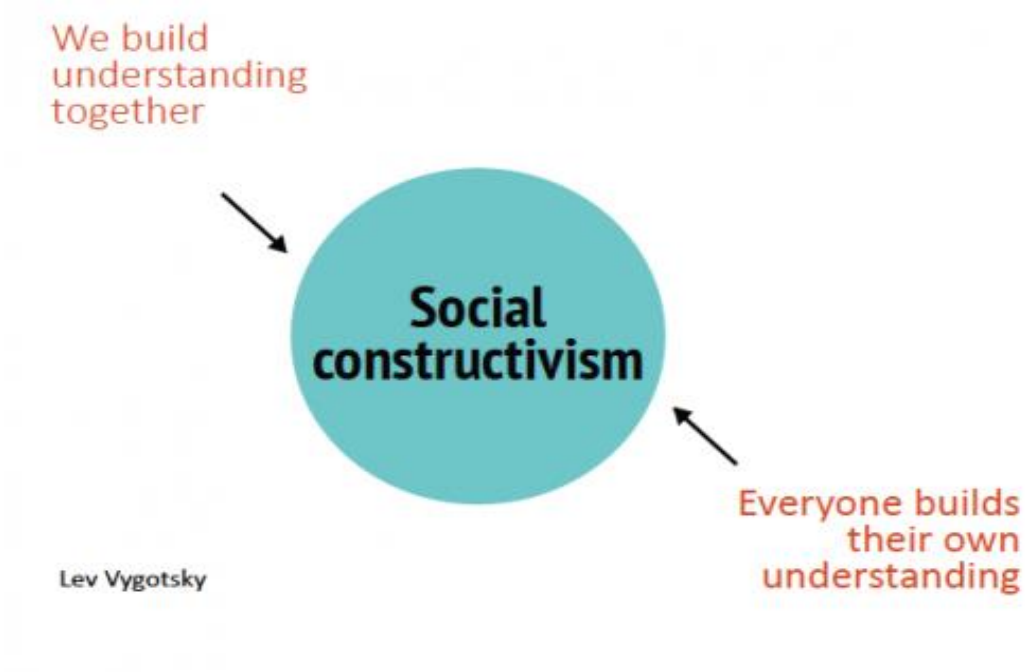


Figure 2.1. Social constructivist diagram (Lev Vygotsky, 1978)

Using a social constructivist paradigm (Figure 2.1) (Vygotsky, 1978; Mertens, 2010; Denzin & Lincoln, 2011; Creswell & Poth, 2018), this study considers the complexity of livelihood

in a holistic manner to understand the lived experiences of local people and their interactions with each other. Social constructivism emphasizes that knowledge and understandings are jointly developed by individuals through the process of social interaction within its context (Creswell & Poth, 2018). Further, it argues that there are multiple realities about knowledge among people (Kim, 2001; Merriam, 2009; Creswell & Poth, 2018). Social constructivism also views knowledge as a socially and culturally constructed human product within the environment in which they live.

As discussed by Guba and Lincoln (2012), paradigm consists of four philosophical assumptions; ontology, epistemology, axiology, and methodology. Methodologically, this study relies on a case study with a mixed-methods approach i.e. qualitative and quantitative bio-physical assessment. The methodology for both approaches is described in depth later in the thesis. Ontologically, this study believes that there are multiple realities; thus reality is subjective to each participant (Guba & Lincoln, 2005). Since there are many realities, social constructivism epistemologically embraces insider approach as such researchers try to study the reality through direct involvement of study participants (Guba & Lincoln, 2005; Creswell & Poth, 2018). Axiology in social constructivism suggests that the study is guided by the understanding and beliefs of the participants while researcher's knowledge is an important aspect for shaping the entire study (Guba & Lincoln, 2005; Creswell & Poth, 2018).

2.2 Researcher as Instrument

While utilizing qualitative inquiry, the researcher is considered an instrument of data generation (Denzin & Lincoln, 2011). The researcher is instrumental in shaping the entire research process from the beginning in the selection of cases, to the methods of data generation and finally,

the interpretation of data generated with respondents to provide meaningful information to readers (Denzin & Lincoln, 2011).

Although the research is centered on the views and meanings generated by participants, the researcher's voice is still present throughout the process. As a researcher, we bring our values, knowledge, experiences, meanings and personal beliefs that influence the entire research process and outcomes (Ely et al., 1991). These personal beliefs and knowledge cannot be separated from the researcher in the inquiry process. Therefore, it is important to state our positionality and viewpoints for readers to have a clear view of the standpoint as a researcher in the study (Denzin & Lincoln, 2011). The following section provides a brief introduction of myself and my views on the communities I studied to better understand my stance on the research.

I was born in a remote village called Tukuche in the Mustang district of Nepal. The district is famously known as "हिमाल पारीको को जिल्ला" (the district beyond the Himalayas). I spent 14 years as a child in Mustang where I grew up climbing mountains, collecting firewood, and riding on horses in the meadow. After completing secondary level school, I moved to Kathmandu (the capital city of Nepal) for higher studies and then to Pokhara for my undergraduate studies.

The village was nearly a week's walk from the closest city. I still remember walking with my parents with a small backpack on my back - I used to fake not being able to walk so my father would carry my backpack for me, especially while climbing uphill. Every year we used to descend south during the winter break (January – March). There was a village on the way down called Rupshe Chhahara (named after a very popular waterfall nearby the village), which used to be my favorite spot to stop by and drink Fanta (my favorite cold drink). The walking trail was very popular among foreigners known as Annapurna Circuit Trek. I remember a massive number of trekkers on the way every year when we headed south in winter.

But the place has dramatically changed now. Back then, we used to live in complete isolation without having seen a motor vehicle, but now with the completion of a road connection, it is normal to see heavy traffic. Trekking tourism was a major source of income at that time. But lodges that once received a heavy number of trekkers on the trail have been completely shut down now. It saddens me how the walking trails have been built down and widened into a dusty road. What saddens me, even more, is how the trekking tourism is completely wiped out after the road arrived as the region was once listed as Nepal's best trekking destination (https://www.lonelyplanet.com/nepal/annapurna-circuit-trek). Even though the motor road is essential for development, the rampant construction of the road has now completely shrunk the trekking tourism in the region. The dusty vehicle road has made it impossible for trekking on the trail even if the travelers want to walk.

From the very beginning of my childhood, I was fascinated by nature. I had already started being curious about the mystery of nature and wanted to learn more. In our school, we were taught to explore the nature we live in besides just solving mathematics or doing chemistry experiments in the lab. My teachers were there to teach us about the importance of the environment. They would always encourage us to contribute to conservation in all possible ways, even if with just a small effort. In the primary level, there was a course where we used to learn the basics of agricultural works. Throughout the one-year course, my teacher would teach us about crops and the whole agricultural process beginning from sowing to harvesting. Students were divided into groups, and each group had a piece of farmland assigned where we had to grow crops and a variety of green vegetables and apple trees. By the end of the school year, teachers would evaluate our work and the best group was rewarded with a prize. In this way, I learned about the process of growing food and its significance to help us sustain our livelihoods since my early childhood.

In 1992, Mustang district came under the governance of Annapurna Conservation Area Project (ACAP) with its headquarters located in Jomsom village (three hours away from my village on foot). Since then ACAP has contributed immensely to conservation education from the school level. Every year they used to organize awareness programs through intra-school as well as inter-school activities which took the form of quizzes, contests, debates, essay writings, etc. Another important program that ACAP occasionally organized was an environmental cleaning campaign. In addition, ACAP developed an environmental and conservation textbook that was taught at our school. Conservation education being the major program, ACAP would promote awareness activities with the belief that education is the most effective way to change people's attitude towards conservation. I believe that my childhood and these activities played a vital role in becoming who I am and where I am now.

From the time of my early childhood days in school, I developed a passion for working in environmental conservation. As I grew up, my passion had already become an inseparable part of my life. Later, after completing my high school degree I joined the Institute of Forestry, and after that, there was no looking back. During my undergraduate study, I invested most of my time in conservation education with field visits and observations. My childhood intimacy with nature along with my undergraduate education in Forestry Science encouraged me to pursue my career as a conservationist.

While I visited home frequently for vacations while in college, I returned to live in Mustang after completing my undergraduate studies in 2015. This time I went further north of Mustang, into the Upper Mustang region. I started working as a research assistant at ACAP. It was so fortunate for me to end up going back to the same place where I grew up as a child and working for the same organization that first taught me the importance of conservation. I had never been to

Upper Mustang before, but I had my uncle and aunt there who were teachers at the school in a village called Chhoser. So, although I had not been there before, I was familiar with the Upper Mustang region because of my relative's stories. I remember my uncle and aunt told me it was a week-long walk from Tukuche to arrive in Chhoser at that time. But by the time I went there, the region was already connected with road. So, it just took me a day to arrive at Upper Mustang by jeep from Jomsom.

As a research assistant, my job was to prepare the conservation area management plan for seven villages in Upper Mustang. I had to visit every village and hold meetings with local people to gather data for the renewal of the operational plan. Additionally, I had also served as an assistant to prepare a local climate change adaptation plan for communities. It was back when I came to know about the environment and the livelihood of the people in the region. I thought I had a very rural life in my childhood, but after working with the people in these Upper Mustang communities, I knew how they were living in a harsh environment with the least resources that nature had offered to them.

I kept hearing about the changes that had happened in the communities as I visited every village there and how they adjusted their livelihood amidst those changes. Some said they had been seeing less snowfall than before, some told me that they had not received as much help as expected from the government. While some would be seriously concerned about drying out the village's water resources. Furthermore, I came to know about the villages (Samzong and Dheye), which were in the process of relocation to a new site after the water sources completely dried out in their villages. It was a serious issue. Additionally, while initiating the relocation process, they were facing many difficulties such as not having enough government support, lack of financial support, and most notably not being able to leave the place where they spent their entire life. It

was high time finding solutions as people were still living in a state of dilemma while envisioning a better future somewhere else.

My stance on this study was shaped by numerous major incidents and experiences with the place where I grew up, the institutions which taught me about conservation, the organization for which I worked and, most importantly, the communities where I worked with after completing my undergraduate degree. This research is another chapter in which I unfold the complex problem I first encountered while working in the rural communities in Mustang, Nepal. Under the umbrella of qualitative research, I tried to understand and present the complex livelihoods of my case study communities by choosing the most appropriate and context-sensitive data generation methods and an effective way of analysis. While my knowledge, experiences, and personal beliefs greatly influenced the research process, I use my background to understand the views and meanings generated from participants. Recognizing my own stance as a researcher, I tried my best to describe and understand experiences as close as possible to how the participants felt and lived it (Sherman & Webb, 1988).

2.3 A Mixed Methods Case Study Research Methodology

> *"A case study is a (research) approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information and reports a case(s) description and themes." (Creswell & Poth, 2018, p.96)*

Guided by a social constructivism paradigm, this study adopted a case study methodology to gain an in-depth understanding of the ways people interpret their lived experiences, how they construct their world, and what meanings they attribute to their experiences (Merriam, 2009). As such, through the "emic" perspective, this study is interwoven with rich description, explanation,

and understanding of the experience and the actions of local people regarding livelihood strategies in their own context (Gau, 2017).

Drawing upon the research questions, the purpose of research, and paradigm, this research employed a case study methodology that incorporates the use of mixed data generation methods (Stake, 1995; Creswell & Poth, 2018; Guetterman & Fetters, 2018; Yin, 2018) to gain an in-depth understanding of local perceptions of rural livelihoods in response to changing social and environmental conditions. The study utilized qualitative and quantitative data generation methods to gain an in-depth understanding of the specificity and complexity of the case in its bounded system while investigating activities and interactions based on its context (Stake, 1995).

This study applied a single case study approach (Figure 2.2) where a remote community: Yara village was chosen as the case in order to explore the livelihood strategies adopted by local people. Moreover, the case study approach represented the current and real-life situation in its context of the community (Creswell & Poth, 2018). The case was bounded in space while situated in the remote Himalayan region of Nepal. As stated by Yin (2018), this study implemented a holistic design with a single unit of analysis i.e. community as a whole.

The study utilized multiple sources of information--qualitative and quantitative to gain an in-depth understanding of the livelihood strategies used by local people in order to respond to social and environmental pressures. Qualitative data (described in detail in section 2.4) data was generated through the use of semi-structured household interviews, key informant interviews, participatory group discussions, direct field observations, and archival evidence (Creswell & Poth, 2018; Yin, 2018). Quantitative data sources included remote sensing of natural resources (vegetation and snow/ice cover) and meteorological datasets. The quantitative portion of this study—including methods, results, and interpretation—is described in detail in chapter 5.

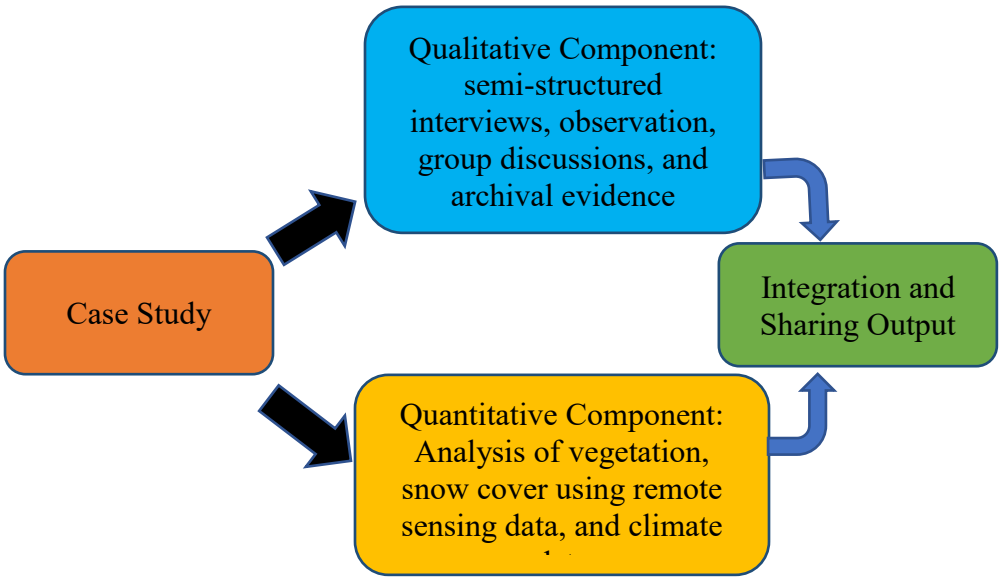


Figure 2.2. A case study methodology using mixed methods (Yin, 2018)

Qualitative data generation methods provided an elaborate description of lived experiences through an inductive process that included participants as part of the research process and accounted for the emergence of questions, analysis, and interpretation of data (Creswell & Poth, 2018). Moreover, the flexible nature of qualitative inquiry allowed us to study complex human dimensions with an iterative process of re-examining questions and data generation tools as new insights and knowledge emerged in the field (Merriam, 2009).

On the other hand, the quantitative component enhanced the findings from the qualitative component of the study through integration and triangulation (Creswell & Poth, 2018). The research employed the concurrent triangulation strategy as Morse (1991) indicated: both data collection techniques were used independently during the data generation process, but the results were mutually complimentary during the analysis. In addition, in this study, the quantitative component facilitated in the assessment of resources that were not possible or time-consuming task through qualitative methods. Quantitative biophysical data helped verify important observations and interpretations of participants about the changing conditions.

2.4 Qualitative Data Generation Methods

In case study research, data generation is typically an extensive process drawing on several information sources and data generation techniques or methods (Creswell & Poth, 2018). Case studies include a series of interconnected activities designed to generate useful information to answer emerging research issues. Prominent case study research scholars (Creswell & Poth, 2018; Yin, 2018) have recommended different types of data generation sources, according to research questions and the context of the study. By following the recommendations, multiple qualitative data gathering methods including archival evidence, key informant interviews, semi-structured household interviews, participatory group discussions, and direct field observations were utilized (Creswell & Poth, 2018; Yin, 2018). Multiple data generation methods allowed us to triangulate across sources and methods while facilitating an in-depth understanding of the study.

In qualitative methods, data generation is not only limited to the methods we use but involves much more. It begins with gaining permission to conduct the study, choosing a quality sampling strategy, the use of appropriate data generation tools and storage system and the consideration of ethical issues that may arise during the study. It further includes a constant process of reflection of the research process, the concepts being generated, and the lessons learned.

2.4.1 Gaining Entry and Building Trust

With the help of Mr. Santosh Sherchan (Conservation Officer, ACAP), an important gatekeeper for my fieldwork, I solicited permission from several key organizations, including the Department of National Park and Wildlife Conservation (DNPWC) in Kathmandu and the Annapurna Conservation Area Project (ACAP) in Pokhara, as the study region falls under the

authority of the Conservation Area in question. After completing all these necessary legal procedures, I was ready to embark on a journey to conduct my fieldwork.

I arrived in Jomsom (the headquarters of Mustang district) on the 30th of May 2018. It had already been dark the time I arrived there, so I just decided to get some rest that day. The following day, after giving prior notice through a call, I went to the ACAP unit office to have a meeting with the chief conservation officer at the office. I handed the permission letter issued from the DNPWC and ACAP. As per the rules it was required to notify the ACAP office in Jomsom about the study and the timeline of the research process.

Before visiting the community, I conducted a series of key informant interviews which provided a wealth of information about the case study community and the Upper Mustang region as a whole. The first few key informant interviews helped to identify other individuals from the region who could subsequently become key informants. I felt like I was already building a snowball which was in the initial phase of its sampling process (Miles et al., 2014).

On the 1st of June, I set out for Upper Mustang. After a day of bumpy jeep ride, I made it up to Tsarang. It was the stop up to where the Jeep service was available. The following day I headed west of Tsarang towards Yara. On the second day of June 2018, I lastly reached Yara after a 5 hours hike through the barren landscape of Upper Mustang.

In Yara, I was introduced to the headmaster (Male) of the local school. He helped me to get initial access to the village by familiarizing me to the *mukhiya* (village head). I stayed at the village head's home, which happens to be a lodge for tourists visiting the village. The following day, I called for a meeting at the village head's house and introduced myself to the community. I described the research work, its objectives, and how people could benefit from this study. The following days I spent in the community gaining a better feel of the place, and gaining entry; days,

I took part in several community events. It helped me to learn more about everyday life. That also ensured that I was seen and accepted in the village prior to beginning interviews and group activities.

Above all, getting help from the youngest son of the village head was the most important way of gaining entry and building trust during household interviews. He acted as a facilitator for me to conduct interviews. He introduced me to every household in the village. Generally, people in the village were not so outspoken. So, without his help, I could not have managed to get their valuable time for the interview. There was an obstacle -- the language barrier – that hindered my direct involvement during some interview processes. There were two respondents who only spoke the Tibetan language. Both were elderly people who could neither speak nor understand the Nepali language. In these two instances, I required the support of the youngest son of the village head; he translated and asked interview questions to the local people while doing the household interviews. In return, he would do the same and translate people's response in Nepali for me. Nevertheless, other respondents (younger generation) were capable to understand and speak Nepali, so I was able to talk to them directly. However, people felt at ease to speak to and easily understood my motive of research if he spoke in the Tibetan language at first prior to the beginning of the household interview. Therefore, this help was key to gaining entry and building trust in the first place.

Another way of getting to know people was to randomly meet them through informal conversations. This usually took place in various settings such as while people were working in their farmlands, getting wool from the goat and sheep, fetching water at the tap, etc. Once, I joined the village head's son on a journey to high rangelands to collect cattle dung. I also offered help to

people when needed. However, the gaining entry method was a continuing process throughout my research that only ended when I departed the study village after the fieldwork was completed.

2.4.2 Participant Selection Strategies

I used snowball, also called chain referral (Miles et al., 2014), to select participants for key informant interviews. These types of interviews took place with personnel from various institutions and organizations.

For the household interviews, a member of each of the households was interviewed. While doing household interviews, only participants 18 years of age or older were selected. Additionally, I ensured to identify a diverse range of participants (both male and female) for interviews to avoid any potential marginalization of voices. The qualitative data generation process was carried out in three phases (Figure 2.3).

Phase 1 included gathering and analyzing archival evidence such as reports, newsletters, journals, ACAP's annual reports, newspaper articles, videos, maps, conservation area operational plan, etc. to get background about the livelihoods of the local people, and rich information about the context. I scanned documents and imported into the NVivo 12 Plus © database. Procedure and protocol for collecting and summarizing archival evidence can be found in Appendix A.

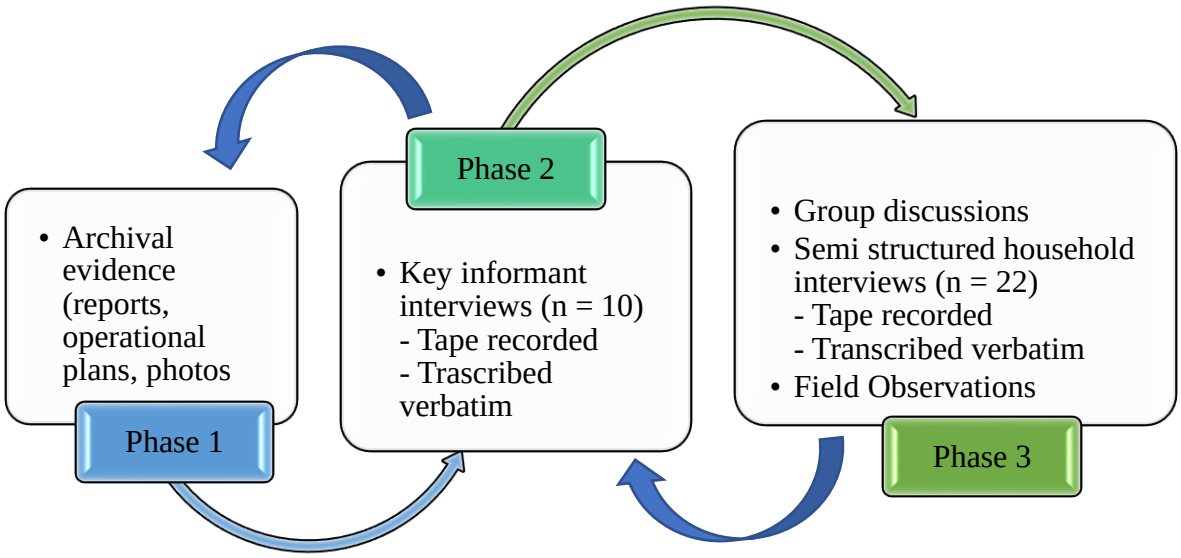


Figure 2.3. Different phases of the qualitative data generation process

During **Phase 2,** I conducted a total 10 in-depth semi-structured key informant interviews with personnel from various sectors and organizations such as ACAP staff, local political leaders, social workers, school teachers, and local non-governmental organization representatives. I used snowball sampling (Miles et al., 2014) to select the key informants. This allowed me to get recommendations of other potential persons who would be excellent key informants that could provide critical information to understand the context and aid in the gaining entry process. I documented each interview using both a tape recorder and detailed researcher notes. I later transcribed interviews verbatim (Kowal & O'Connel, 2014) and imported them into NVivo 12 Plus ©. Procedure and Protocol for the interview are in Appendix B.

For **Phase 3, w**hile in the study communities, I used participatory group discussion initially for gaining entry and building trust among the local people. The major purpose of the discussion was to gather local people and inform them about the study. I also brought some of my research questions to the group discussion about livelihood strategies. This group discussion also acted as a medium to triangulate people's perceptions with the individual interview responses (Miles et al., 2014).

I conducted semi-structured interviews (Creswell & Poth, 2018; Flick, 2018) with all households in Yara (n=22). I conducted most of the interviews in the participants' homes, except sometimes in their farmland while reducing any risk and making them as comfortable as possible. Interviews lasted from seven to forty-five minutes. Local people were occupied with their work most of the time during the seasonal agricultural work (May-July). Therefore, I tried to make the most out the limited time provided to me and considering the fact that they have devoted precious time for my study regardless of their busy schedules. I used the Nepali language for most of the household interviews. I used the Tibetan language for some interviews as some elderly participants could not speak Nepali; had a local translator for supporting the process. I conducted household interviews and tape-recorded them. I also kept a notebook to write down key ideas during interviews—jotted notes. I later transcribed interviews verbatim (Kowal & O'Connel, 2014) and coded in NVivo 12 Plus ©. I also kept a reflective journal to write down my thoughts after each interview and later at night while I went through listening and reading interview notes. An example of the procedure and protocol is in Appendix C.

I used direct observations method (Creswell & Poth, 2018) in which I actively observed activities done by the local people. While living in a local lodge (my accommodation), I spent time talking to house members in the dining hall and around the village where I roamed around on a daily basis. I had casual conversations at dinner time with members of the family, with the school headmaster in school and with students, at the public tap while women were fetching water, with the men while they were extracting pashmina from sheep and goat in the paddocks, as well as in the agricultural fields. Such types of interactions helped me not only to learn about the daily living of local people, but it also allowed me to gain entry and build rapport with local people. I even

used photography as a record-keeping tool in the field to make sure not to miss valuable contents. Procedure and Protocol for field observations are in Appendix D.

2.5 Ethical Considerations and Confidentiality

While doing qualitative research we are probing human existence in detail, which often is directed towards the intimate aspects of people's lives (Bailey, 1994). Therefore, during the course of the research, it is important to inform the participants what they are being studied about and ensure that no harm is caused to them (Miles et al., 2014).

As per compliance of University of Maine policy and procedures for the protection of human subjects during research, this study was approved by the UMaine's Institutional Review Board (IRB) for the Protection of Human Subjects. As for ethical consent, participants were asked to sign consent forms before the interview process (Appendix E and F). The information in the consent form was read out for illiterate respondents and verbal permission was obtained. Additionally, participants were informed that participation was completely voluntary, that they can be stopped any time throughout the study, their responses would only be used for research and academic purposes, and their identity would be confidential unless they agreed to be cited by name. Participants were requested to grant their permission to use photographs and videos for presentation and publication purposes. There were no cases where a participant refused to participate in an interview or group discussions. To ensure the privacy and confidentiality of data in the study, interview responses, photographs, videotapes were stored in a secure environment (i.e. locked office), only to be accessed by the investigators.

2.6 Database Creation and Analysis

I approached data analysis as an ongoing and cyclical process throughout the research (Ely et al, 1991). I used different forms of data analysis throughout the research process, which are described in this section. Moreover, I embraced the approach of data reduction, data display, and drawing and verifying conclusions with data (Figure 2.4) (Miles et al., 2014).

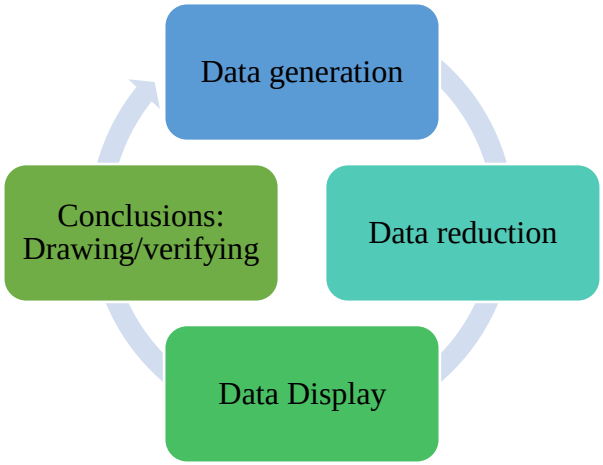


Figure 2.4. The cyclical and iterative process of data generation and analysis (Miles et al., 2014)

Data analysis began with the compilation, organization, and synthesis of archival evidence before conducting interviews and participatory group discussions; this strategy allowed me to identify a historical scenario of the livelihoods of the local people (Miles et al., 2014). I used a document summary form to analyze archival documents, allowing me to organize and label each piece of evidence.

In qualitative research, data analysis is a recurring process that occurs simultaneously with the data generation process. I used several methods to organize and analyze data during data collection, such as reflective journals and analytic memos to quickly summarize what was included in each of the interviews and group discussions. I used NVivo 12 Plus © to analyze the data generated through all the social science research methods. NVivo is a Computer Assisted Qualitative Data Analysis Software (CAQDAS), which facilitated the analysis of data while

assigning codes, describing themes and categories, and creating textual units of analysis according to keywords and phrases (Bazeley & Jackson, 2013). NVivo also helped to group data that met a set of criteria and to import, retrieve and save for further analysis. My NVivo database consisted of textual and graphic materials (photos and videos) that were obtained from each of the data generation methods I was using in this study.

Data analysis started as I was transcribing and drafting interviews and reflective journals. All interviews were transcribed in Nepali because I wanted to stay close to the meanings of the participants while capturing their voice as they shared their lived experience. However, I assigned nodes in English when coding and the node description was also written in English.

I began with open coding, mostly relying on using in vivo codes (Bazeley & Jackson, 2013) to ensure that participants' perceptions and knowledge were captured and heard directly as shared during the interviews (Bazeley and Jackson, 2013). In vivo codes helped to initially identify and highlight emerging patterns while staying close to the participants' words. In vivo coding is considered appropriate at the beginning when conducting a study aimed at reconstructing meanings about the phenomenon from participant's own perspectives (Miles et al., 2014).

During the second cycle of coding, I conducted pattern coding to help group and summarize initial codes from the first cycle coding into categories and themes (Bazeley & Jackson, 2013). This structure of categories and themes helped me to explain the perceived experience of the phenomenon lived by the local people of the study region.

The second coding cycle was further enhanced by conducting various queries in NVivo 12 Plus © such as text search, word frequency, matrix coding, etc. Queries helped me to explore patterns in the data and further investigate hunches as I progressed through the analysis process. Text queries helped to search for words or phrases consistently associated with each other, while

word frequency queries helped to list most frequently occurring words or concepts in the data. After several text and frequency queries to explore patterns, I conducted coding queries. These coding queries helped me to explore patterns and identify connections in the data. The outputs from my queries and coding included matrices and cognitive maps to synthesize and organize data and later assisted in generating categories (Appendix G).

Finally, drawing from all the patterns and categories, the outputs from the study are presented as results which include a rich description of the case and its context, patterns generated from peoples' perceptions grouped into codes and categories, and collation of meanings portrayed by participants into conclusions.

2.7 Trustworthiness

Trustworthiness in qualitative research means providing enough evidence for the reader to determine if the conclusions are based on the data presented (Merriam, 2009). There are various techniques to assessing the quality of the research process in qualitative research (Table 2.1) proposed by different scholars (Creswell & Poth, 2018; Guba & Lincoln, 2005); for this research, I will utilize trustworthiness strategies associated with credibility, transferability, dependability, and confirmability.

Table 2.1 Techniques for Trustworthiness

Case study term: Trustworthiness	Techniques proposed in the study
Credibility: Provides assurances of the fit between respondents' views and researchers' reconstruction and presentation of the view (Schwandt, 2001)	• Triangulation (Merriam, 2009) • Member checking (Schwandt, 2001; Creswell and Poth, 2018) • Researcher remaining 'close' to data collection (Creswell and Poth, 2018) • Within case participant selection • Cyclical data generation & analysis (Miles et al., 2014) • Researcher native to the country
Transferability: Deals with generalization regarding the case-to-case transfer of information. Allows the audience to relate findings from this particular case studied to other contextually similar cases (Schwandt, 2001).	• Clear criteria for case selection • An in-depth description of the cases (Creswell and Poth, 2018) • A detailed description of methods for data generation and analysis • In-depth interviews (Merriam, 2009)
Dependability: Ensuring that the process of inquiry is logical and traceable and that the researcher kept the process well documented (Schwandt, 2001).	• Data analysis throughout generation (Creswell and Poth, 2018) • NVivo database • Transcription of field notes • Reflective journals, memos • Consistent use of case protocols
Confirmability: Establishes the fact that the data and interpretations are not imaginations of the researcher (Schwandt, 2001)	• NVivo database • Case study methodology • Member checking (Schwandt, 2001; Creswell and Poth, 2018) • Advisory reviewers

I used various techniques to ensure trustworthiness in my study. I utilized multiple strategies that would address the trustworthiness of my study which would ensure that the findings are plausible and completely drawn from the participants' point of view (Guba & Lincoln, 2005). Building trust with participants, learning and respecting their culture were initial steps (Ely et al., 1991). I also did triangulation across data generation methods and across participants to ensure multiple perspectives and factors to be captured and understood (Creswell & Poth, 2018; Patton,

2015). Further, I triangulated qualitative findings; participants' interpretation of the observed changes and quantitative bio-physical results; remote sensing monitoring of natural vegetation and permanent snow cover and analyses of climate datasets, in order to verify the results and to get better understanding of the case. The use of reflective journal was an essential activity to reflect on the whole inquiry process (entry, rapport, data generation) while acknowledging my role as a researcher as instrument (Creswell & Poth, 2018). The reflective journal also served as the bridge between data generation and analysis process, as my questions needed to be re-examined as new insights and knowledge emerged while in the field and consequently data generation methods needed to be changed. Thus, the qualitative inquiry followed a cyclical-iterative process of data generation and analysis, whereby analyses led to changes in the data generation process (Miles et al., 2014).

Member checking (Creswell & Poth, 2018) was another technique that I used to ensure the quality of data being generated. During the interview, I also summarized people's response and took note of their responses regarding the synthesis of ideas. Most of the member checking occurred simultaneously during the interview. I also used peer debriefing (Ely et al., 1991) where I would discuss the analysis process and interpreted my data along with my advisor and peer graduate students. The peer debriefing process helped me become more aware of my positionality while interpreting the data. While I was in the field, my communication with my advisor was limited due to the inaccessibility of the internet in the study area. I nevertheless ensured my continued contact with Mr. Santosh Sherchan, who provided his invaluable time and effort during my fieldwork.

CHAPTER 3: CASE STUDY CONTEXT

3.1 Overview of the Country- Nepal

3.1.1 Geographic Context

Sandwiched between two Asian giants -- Tibet Autonomous Region of China to the north and India to the south, east, and west (Figure 3.1) -- Nepal traditionally has been characterized as "a yam caught between two rocks" (Savada & Harris, 1993). Roughly rectangular in shape, Nepal extends about 885 km from east to west and 145-241 km from north to south. Nepal has an area of 147,181 sq. km (56,827 sq. miles), which is slightly larger than the state of New York in the US (Central Intelligence Agency, 2019). Kathmandu is the capital and the largest city in Nepal.

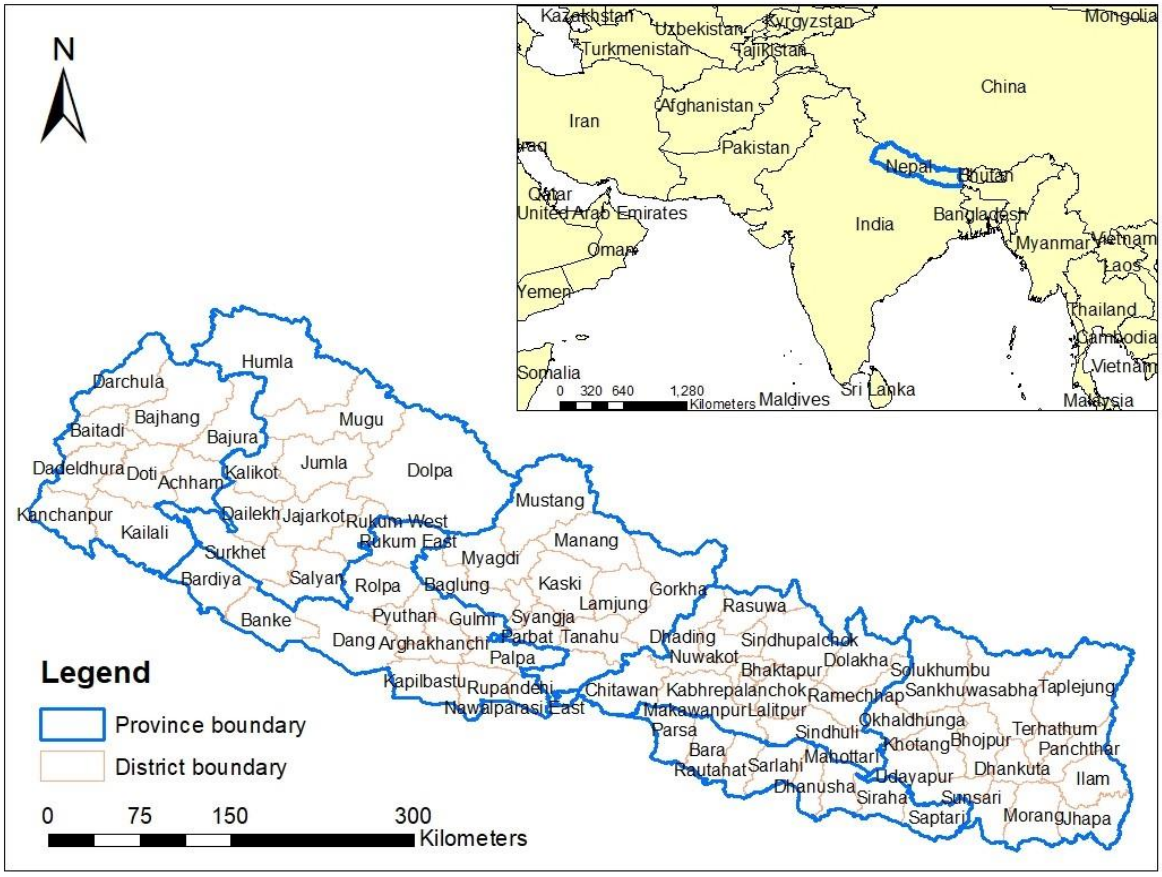


Figure 3.1. Map of Nepal with its location in the World map (Source: Author)

Despite being relatively small, Nepal has remarkable diversity in topography and climate ranging from southern subtropical to polar ice atop high mountain peaks (Bishop, 1990). Within a short distance of 150 km south to north, the altitude varies from 60 meters above sea level (m a.s.l. hereafter) (197 ft.) elevation in the tropical Terai (the northern rim of the Gangetic Plain) to Sagarmatha (Mount Everest) - the world's highest mountain at 8,848 m a.s.l. (29,029 ft.) (HMGN/MFSC, 2002). A diverse succession of climatic zones - subtropical, temperate, subarctic, arctic and even desert-steppe environments is found within such narrow cross-section from south to north (Bishop, 1990).

Physio-graphically Nepal is divided into five parallel zones (Figure 3.2 & 3.3) running east-west; Terai (below 900 m a.s.l.), Siwalik zone (900 to 1,200 m a.s.l.), Middle-hills (1,200 to 3,000 m a.s.l.), High-mountains (3,000 to 5,000 m a.s.l.), and High-Himalayas (above 5,000 m a.s.l.) (Figure 3.2 & 3.3) (Land Resources Mapping Project, 1986).

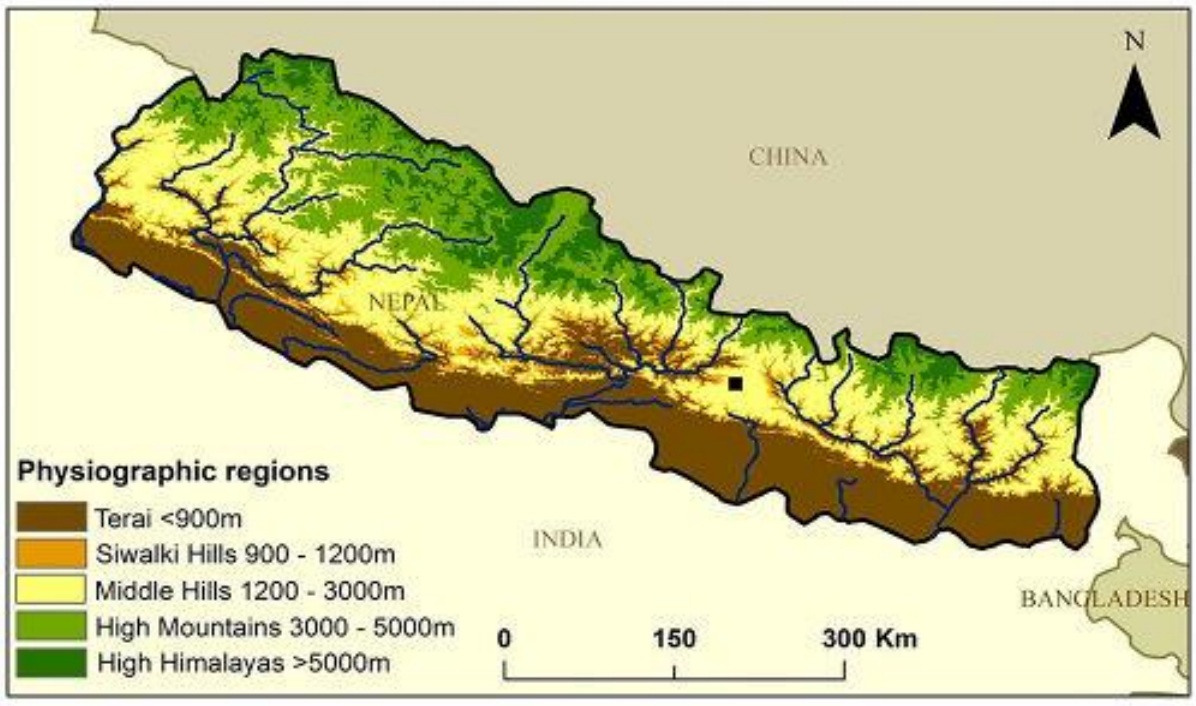


Figure 3.2. Physiographic regions of Nepal (Source: USGS, 2004)

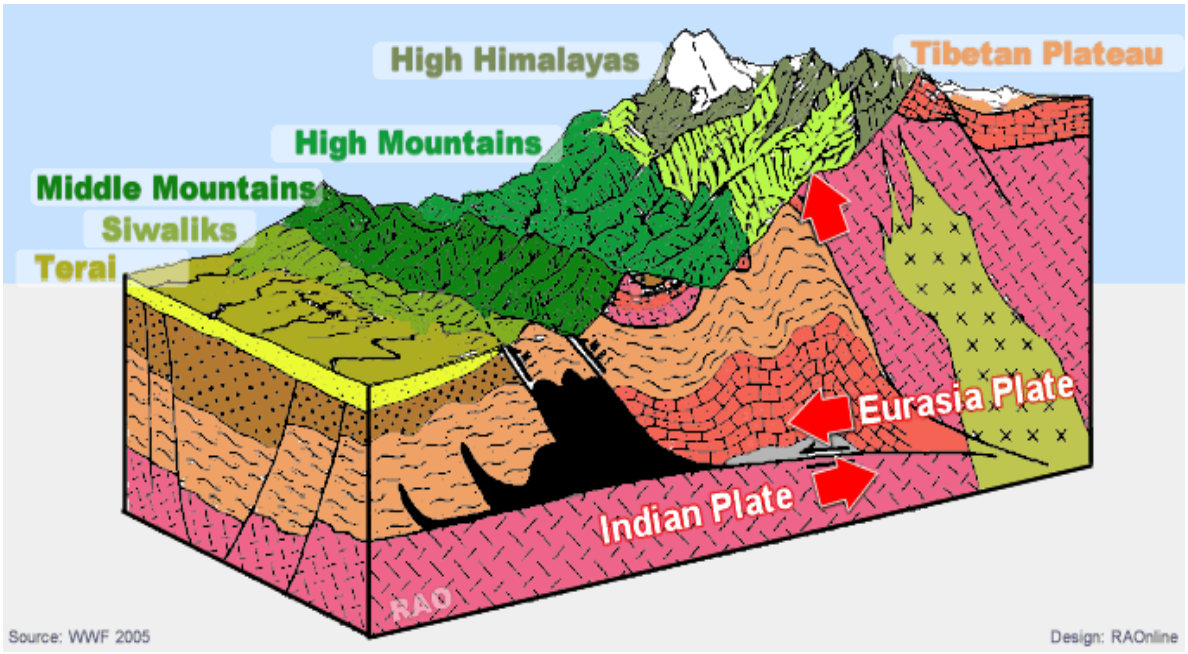


Figure 3.3. Physiographic structure of Nepal (Source: WWF, 2005)

Nepal experiences four seasons (ऋतु): spring or pre-monsoon (वसन्त), summer or monsoon (ग्रीष्म), autumn or post-monsoon (शरद), and winter (शिशिर) (Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015). Spring season begins from March and lasts till May. Summer continues from the month of June until September. Summer is the monsoon season in Nepal, which enters from the eastern part of Nepal and contributes to the main source of precipitation as rainfall. Then comes autumn which lasts from October to November. Nepal experiences winter season from December to February.

Climatic conditions of Nepal vary substantially in accordance with the altitudinal variation, topography, and seasonal atmospheric circulations across the country (Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015). The north part of Nepal has cool summers and severe winters while the south has tropical summers and mild winters (see Figure 3.4a, b, c & d). Summer temperatures in the Terai (southern Nepal) exceed 35°C and in some areas even higher, winter temperatures in the Terai range from 10°C to 25°C. Summers are temperate

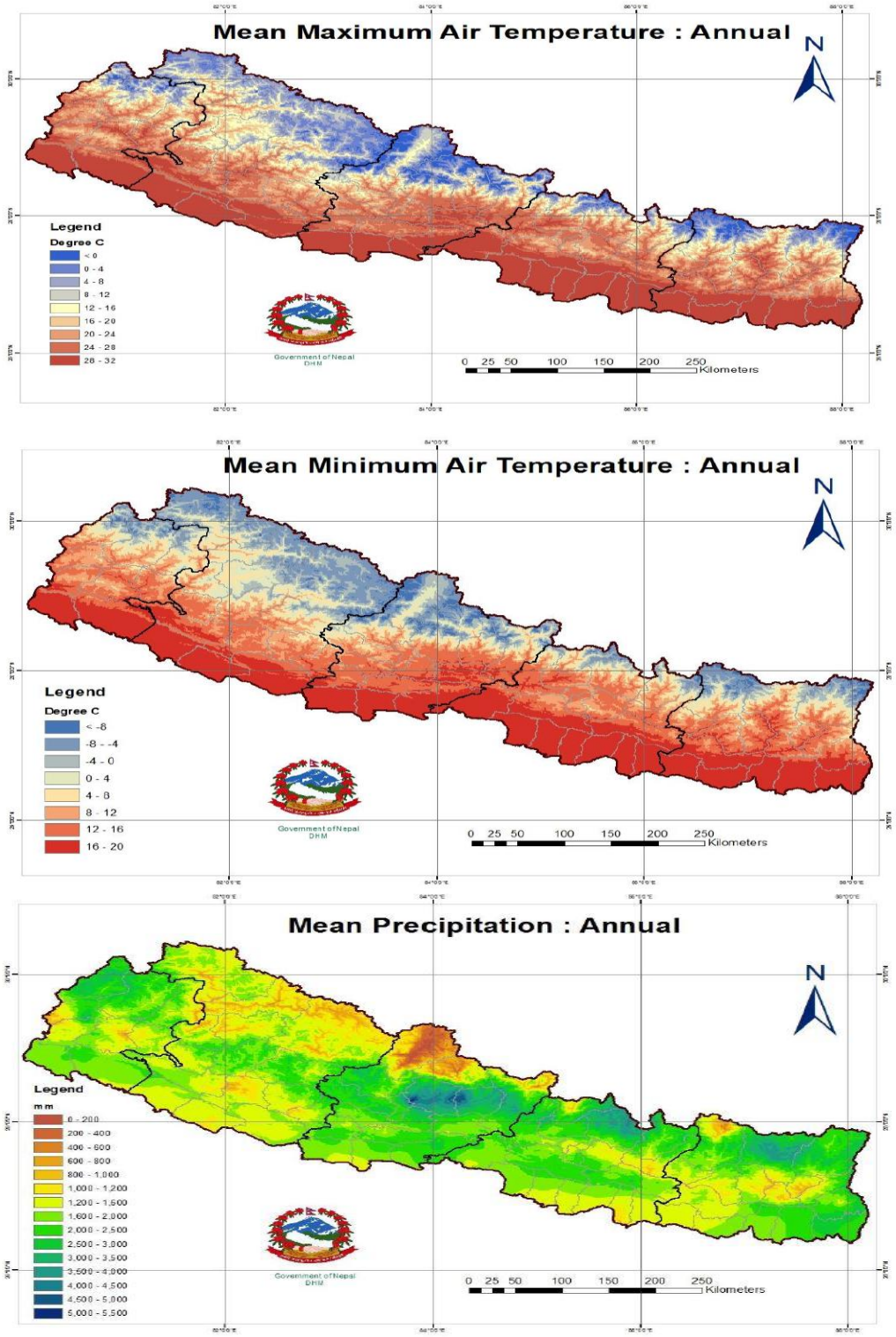


Figure 3.4. Temperature and precipitation distribution over Nepal. a) mean annual maximum temperature, b) mean annual minimum temperature, c) mean annual precipitation (Source: Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015)

(10°C-15°C) in mountainous areas, while winter temperatures drop below subzero. The capital city of Nepal, Kathmandu has a pleasant climate with summer and winter temperature of 20°C-35°C and 5°C-15°C respectively (Department of Hydrology and Meteorology, 2017).

The mean annual precipitation of Nepal is around 1800 mm (see Figure 3.4e). The highest annual precipitation is recorded in Lumle of Kaski district with mean annual precipitation of about 5500 mm (Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015; Department of Hydrology and Meteorology, 2017). The lowest precipitation is recorded in Dhee in the Upper Mustang region of Mustang district with mean annual precipitation of less than 150 mm. Both of these highest and lowest precipitation sites of the country are in the Annapurna Conservation Area (Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015).

3.1.2 Administrative Context

Nepal's first level subdivisions had previously been Development Regions (DR) (Figure 3.5). Each development region was subdivided into zones, each zone into districts, and each district into village development committees. There were five DRs, 14 zones, 75 districts.

After the approval of the new constitution in 2015, the administrative divisions were reconstructed. Now the first level of subdivisions is the provinces that are further subdivided into districts (Figure 3.6), and each district into municipalities and rural municipalities. At present, there are seven provinces, 77 districts, six metropolitan cities, 11 sub-metropolitan cities, 276 municipalities, and 460 rural municipalities.

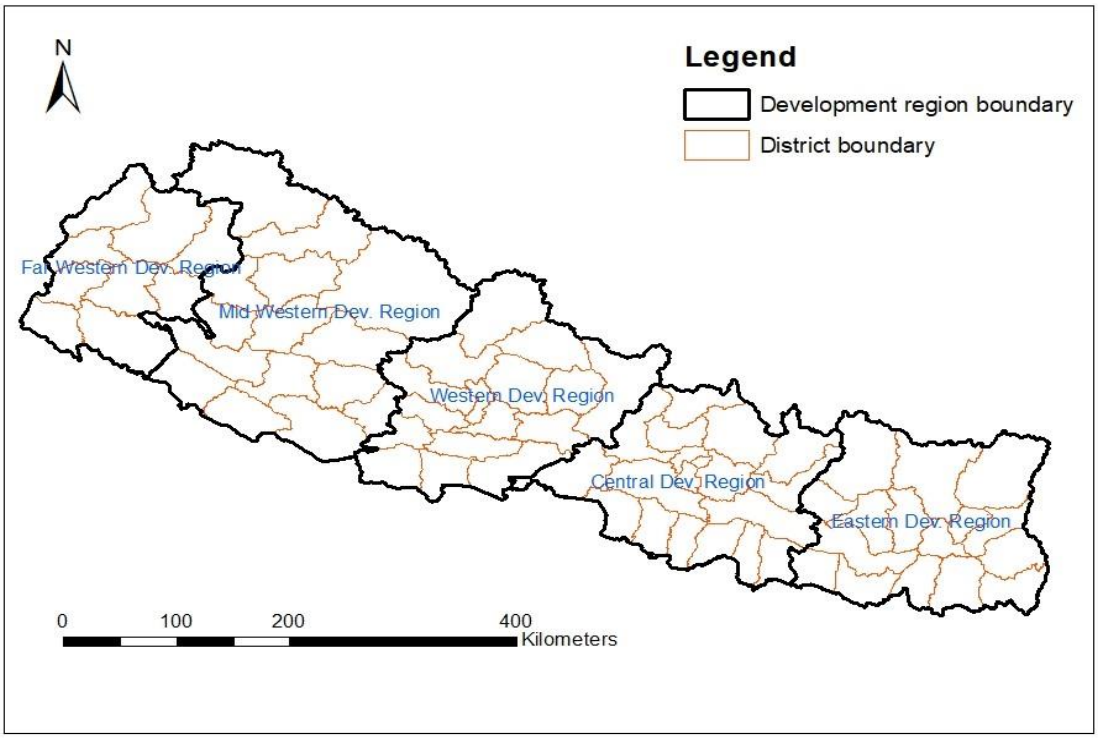


Figure 3.5. Map of administrative divisions of Nepal by an old structure with Development regions and Districts (Source: Author)

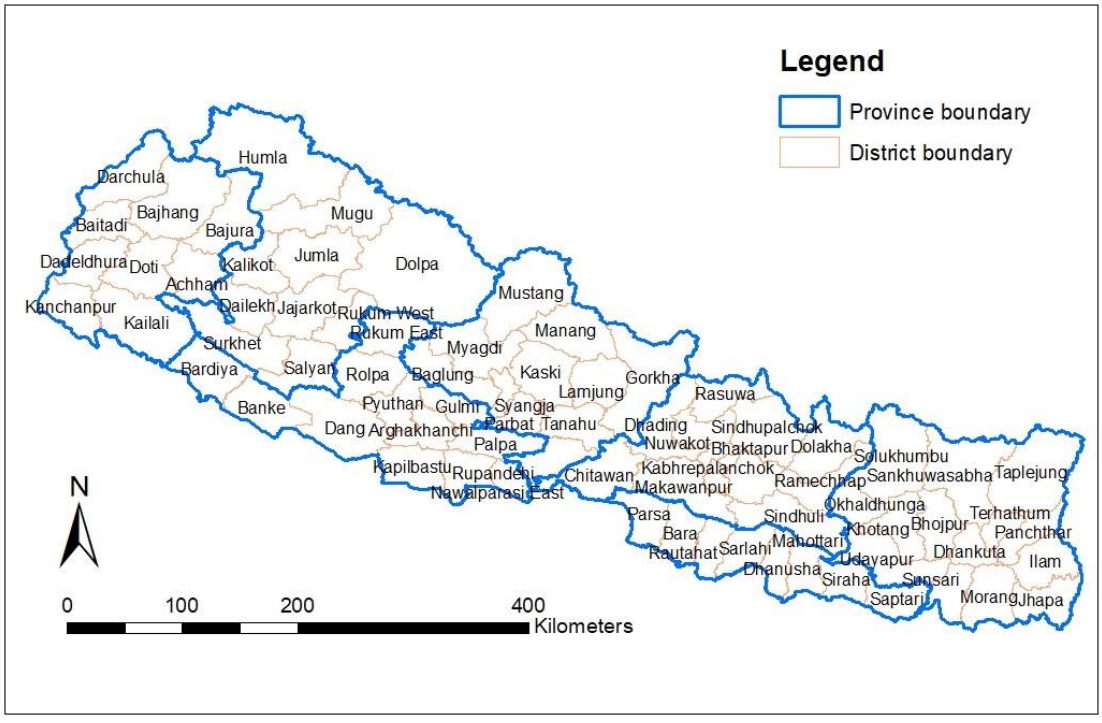


Figure 3.6. Map of administrative divisions of Nepal by a new structure with Provinces and Districts (Source: Author)

3.1.3 Demographic Context

According to the most recent census data (June 2011), Nepal's population is 26.5 million with an average population density of 180 people per sq. km, presenting an average annual growth rate of 1.35% (Central Bureau of Statistics, 2012). The highest population density (4,416 people per square km) is found in the capital city of Nepal, Kathmandu and the lowest (three people per square km) is found in Manang district. According to the latest World Health Organization (WHO) data published in 2018 life expectancy in Nepal is: 68.8 for male, 71.6 for female and total life expectancy is 70.2 at 117th place in world life expectancy ranking (https://www.worldlifeexpectancy.com/nepal-life-expectancy).

Figure 3.7. Visual representation of ethnic diversity in Nepal (Source: http://www.himalmandaptreks.com/caste-system-nepal/)

Just as the varied natural landscapes, Nepal is extremely diverse in terms of ethnicity, language, religion, and culture (Figure 3.7); as such, it is known as a "multi-ethnic, multi-lingual, multi-religious, and multi-cultural country" (Constituent Assembly Secretariat, 2015). A total of 126 castes/ethnic groups, speaking as many as 123 languages spoken as a mother tongue (first language), were reported in the 2011 census (Central Bureau of Statistics, 2012). Nepal presents

an example of being united in diversity throughout history and has maintained its pride as being an independent sovereign nation (Constituent Assembly Secretariat, 2015).

The official language is Nepali (नेपाली), formerly called *Khas Kura* (खस कुरा) (Bandhu, 1989; Constitution of Nepal, 2015). Hinduism (81.3%) is the predominant religion followed by Buddhism (9%), Islam (4.4%), Kirat (3.1%), and Christianity (1.4%) among others (Central Bureau of Statistics, 2012). Until Nepal was declared a secular nation by the Interim Constitution of Nepal 2007, it was referred to as a Hindu Kingdom (Nepali et al., 2018).

3.1.4 Socio-economic Context

Nepal still remains one of the world's poorest and least-developed countries with 21.6% (more than 6 million) its population living under the poverty line (Ministry of Finance, 2018). According to the Human Development Index (HDI) report of the UNDP, Nepal ranked 149 among 189 countries with an HDI of 0.574. However, between 1990 and 2017, the country's HDI grew from 0.378 to 0.574 by 51.9%. Nepal's Gross Domestic Product (GDP) per capita was $849 with a growth rate of 6.7 per year in 2017 (https://data.worldbank.org/indicator/ny.gdp.pcap.cd).

More than two-thirds of the population is involved in agriculture as a primary source of income, and many are subsistence farmers. However, throughout the country agriculture has lost importance as a GDP generation; for instance, in the 2017/2018 period, agriculture contributed to about 27.6% of GDP compared to 29.37% in 2016/2017 (Ministry of Finance, 2018). In the 2017/2018 period, the non-agricultural contribution to the GDP increased to 72.4% from 70.63% in the 2016/2017 period.

The economic survey (2017/18) conducted by the Ministry of Finance, Government of Nepal shows that basic services, such as education and health, have improved over the period from

2016/2017 to 2017/2018. In the 2017/2018 academic year, the net primary - level enrollment ratio was 97.2 percent followed by 92.3% in the basic level as compared to the period of 2016/2017 which was 96.9%, 80.9% and respectively. However, the rate of enrollment in a secondary level decreased to 43.9% in secondary level against 59.8% in the academic year of 2016/2017. A total of 87.9% of the population have access to drinking water and 94.0% of the total population has benefited from basic sanitation services.

3.1.5 Political Context

Nepal has struggled with transitions on multiple fronts over last two to three decades: from a monarchy to a republic; authoritarianism to democracy; and from a centralized government to regional and local self – government (Pyakurel et al., 2012). The country, formerly known as the only Hindu kingdom in the world, is now officially a federal multiparty republic secular nation. On 28 May 2008, nearly 240 years of monarchial rule came to an end by a Constituent Assembly to declare it as a republic country (Constituent Assembly Secretariat, 2015).

In Nepal's history, one of the major events was the Civil War. Popularly known as the Maoist Conflict or Maoist Insurgency (माओवादी जनयुद्ध), it was a ten-year-long armed conflict between the Communist Party of Nepal (Maoist) and the government of Nepal, fought from 1996 to 2006 (Hutt, 2004; Lawoti & Pahari, 2009). The insurgency was led by the Maoist to overthrow the Nepalese monarchy and establish a People's Republic. Over 17,000 people were killed, including civilians, insurgents, the military, police and hundreds of thousands internally displaced (mostly in rural Nepal) during that period (Hutt, 2004). On November 21st of 2006, a decade-long war ended with a peace agreement with the government, leading to Maoist participation in mainstream politics (Gobyn, 2009).

The country has experienced major political transitions since the signing of the peace agreement. There have been frequent changes in leadership with eleven different governments in thirteen years (Lawoti & Pahari, 2009; Pradhan, 2009) However, the prolonged and long-delayed democratic transition of the Himalayan nation came to an end with the parliamentary and provincial election held in 2017 (Khalid & Chughtai, 2017). Five years of a stable government has been formed now and the country has reformed into a federal structure intended to decentralize power from capital city Kathmandu to the newly-created seven provinces and local government units (Khanal, 2015).

3.2 Regional Context: Mustang District

Mustang district is located in the north-western frontiers of Nepal bordering the Tibetan Autonomous Region of China in the north, Dolpa district in the west, Manang district in the east, and Myagdi district in the south (Figure 3.8). The region covers an area of 3,563 square kilometers with the elevation ranging from 1,372 m a.s.l. to 8,167 m a.s.l. (Mount Dhaulagiri is the 8th tallest mountain in the world) (Resource mapping report, 2014).

Located north to the Annapurna (8,091 m a.s.l.) and Dhaulagiri (8,167 m a.s.l.), Mustang falls in the rain-shadow region and is relatively protected from monsoon influences (Fort, 2015). As a result, the region receives very little rainfall which ranges from below 150 mm in Dhee, Upper Mustang to 300 mm annual rainfall in Jomsom (the headquarters) (Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015).

Figure 3.8. Location of Mustang district within Nepal, including boundaries and names of rural municipalities (Source: Author)

Since 1992, the entire district has been designated in the Annapurna Conservation Area (ACA) (the largest protected area of Nepal) and is managed by the Annapurna Conservation Area Project (ACAP) (Craig, 1996). According to the 2011 census, Mustang district has a population of

13,452 people. The district is sparsely populated, with the second-lowest population density (3.8 people/km²) reported in Nepal (Central Bureau of Statistics, 2012).

Traditionally, Mustang district has been divided into two regions- the Lower Mustang and the Upper Mustang (Figure 3.9). Further, the two regions have been sub-divided into four social and geographical regions. From south to north they are Thak Satsae (also known as lower Thak Khola), Panchgaon (upper Thak Khola) and Baragaon (mostly considered part of Thak Khola, sometimes called lower Lo) and Lo Tsho Dyun (also known simply as Lo) (Craig, 1996).

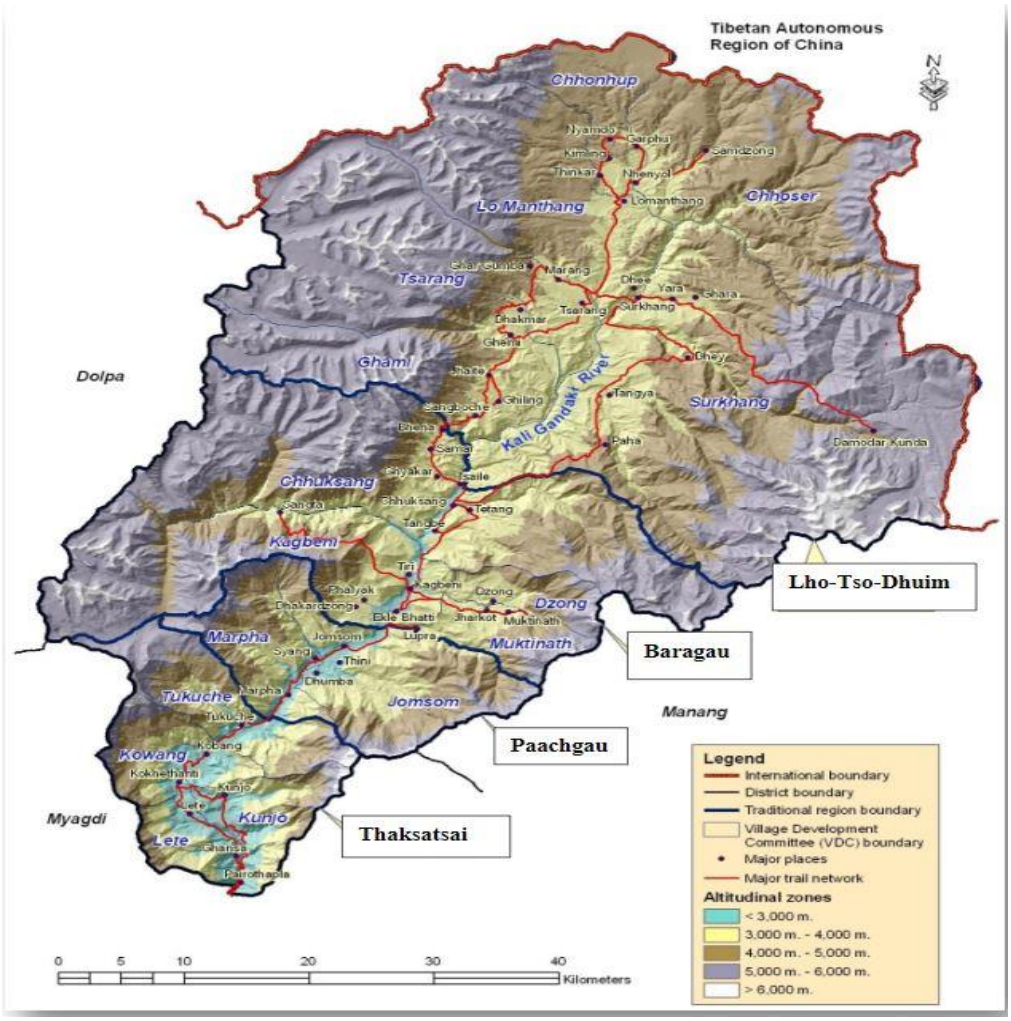


Figure 3.9. Map of Mustang district with its traditional divisions (Source: NTNC/ACAP, 2008)

Administratively, the district belongs to Gandaki Pradesh (Province). It is divided into five rural municipalities (Figure 3.8). The Lower Mustang region comprises three rural municipalities namely Thasang, Gharapjhong, and Barhagaun Muktikshetra. The Upper Mustang region has two municipalities: Lomanthang and Dalome. Located in the Lower Mustang region at an altitude of 2,743 m a.s.l., Jomsom is the headquarters of Mustang district.

The following section covers the description of the Upper Mustang region where our study site is located.

3.3 Sub-regional Context: The Upper Mustang Region

3.3.1 Geography

Situated in the Trans-Himalayan region (entirely north of the great Himalayan range), the Upper Mustang region covers the northern part of Mustang district and borders the Tibetan Autonomous Region of China in north, north-east and north-west, lower Mustang to south and Dolpa, and Manang districts to the west and east respectively (Figure 3.9 & 3.10). It has an area of 2,567 square kilometers and includes the two rural municipalities: Lomanthang and Dalome with a total population of 3,834 (Central Bureau of Statistics, 2012).

Historically, the Upper Mustang region was under the rule of Tibet. In 1380, the region was affirmed as an independent state and established as the kingdom of Lo while Lomanthang as the capital (Jackson, 1984; Peissel, 1998; Dhungel, 2002; Tulachan, 2003). In the late 18th century, during the unification period of Nepal led by king Prithivi Narayan Shah, the Upper Musang (Lo) region was declared as a dependency of Nepal in the quest of conquering all the small kingdoms of Nepal and creating an empire of Nepal (Peissel, 1998; Dhungel, 2002).

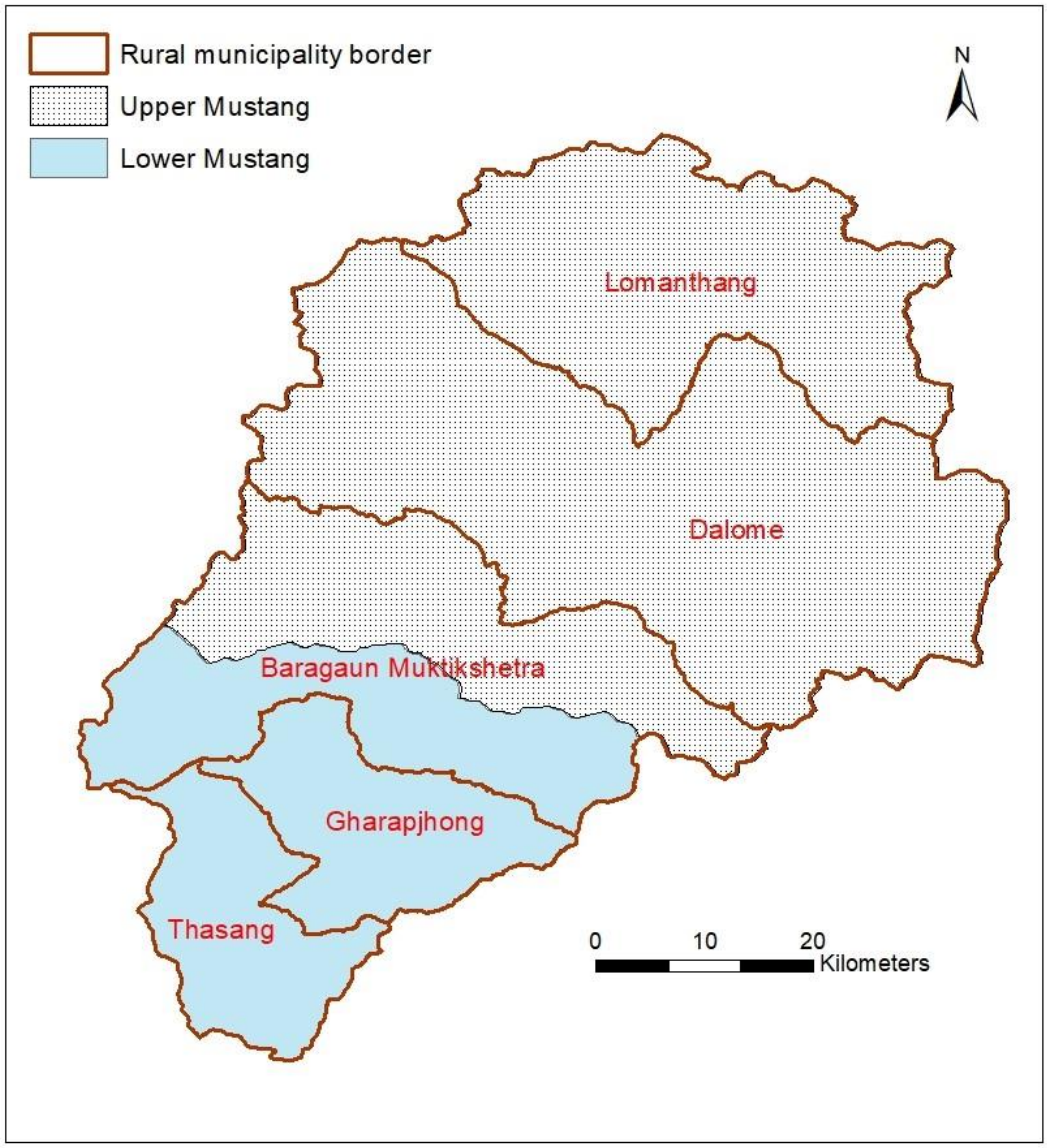


Figure 3.10. Map of Mustang district showing the Upper Mustang region with rural municipality borders (Source: Author)

The elevation ranges from 2,861 m a.s.l. to 6,726 m a.s.l. which mostly comprises high altitude steppe. The habitation zone is between 2,861 m a.s.l. to 4,000 m a.s.l. (Figure 3.11) which is characterized by low temperature throughout the year and snowfall in winter making the Upper Mustang region a very cold place to live (Dhungel, 2002; Tulachan, 2003). The region has very scarce vegetation which comprises subalpine vegetation, and alpine rangelands. Rangelands cover about 40-50% of the Upper Mustang region and it has very limited farmland with only 1.2% for

agricultural cultivation (ACAP, 2010). Plant species such as *Caragana spp., Lonicera spp., Stipa spp., Carex spp., Kobresia pygmaea* (C.B.Clarke), *Kobresia felicina* (C.B.Clarke), *Lagotis spp., Thymus linearis* (Benth), *Corydalis spp., Delphinium spp., and Meconopsis spp*. characterize the rangelands (Chetri & Gurung, 2004). Except for a small patch of forest between Samar and Ghiling villages, there are no natural forests in Upper Mustang (Basnet, 2007). Some orchards like *Populus ciliata* (Bhote pipal) and *Salix spp*. (Bains) (ACAP, 2010) characterize most of the forested area through the plantation.

Figure 3.11. A glimpse of Chhoser village in Upper Mustang situated beyond the mountains (Date: July 2018, Source: Author)

The Kaligandaki River is the major river system that runs southward from Upper Mustang through the Lower Mustang region towards lowlands of Nepal and is fed by tributaries that include Ghami Khola, Tsarang Khola, Chiprung Khola, Ghechang Khola, Tange Khola and Narsing Khola (Pokharel, 2009). There are 32 villages in the Upper Mustang region of which most of the villages are located along these tributaries (Figure 3.12).

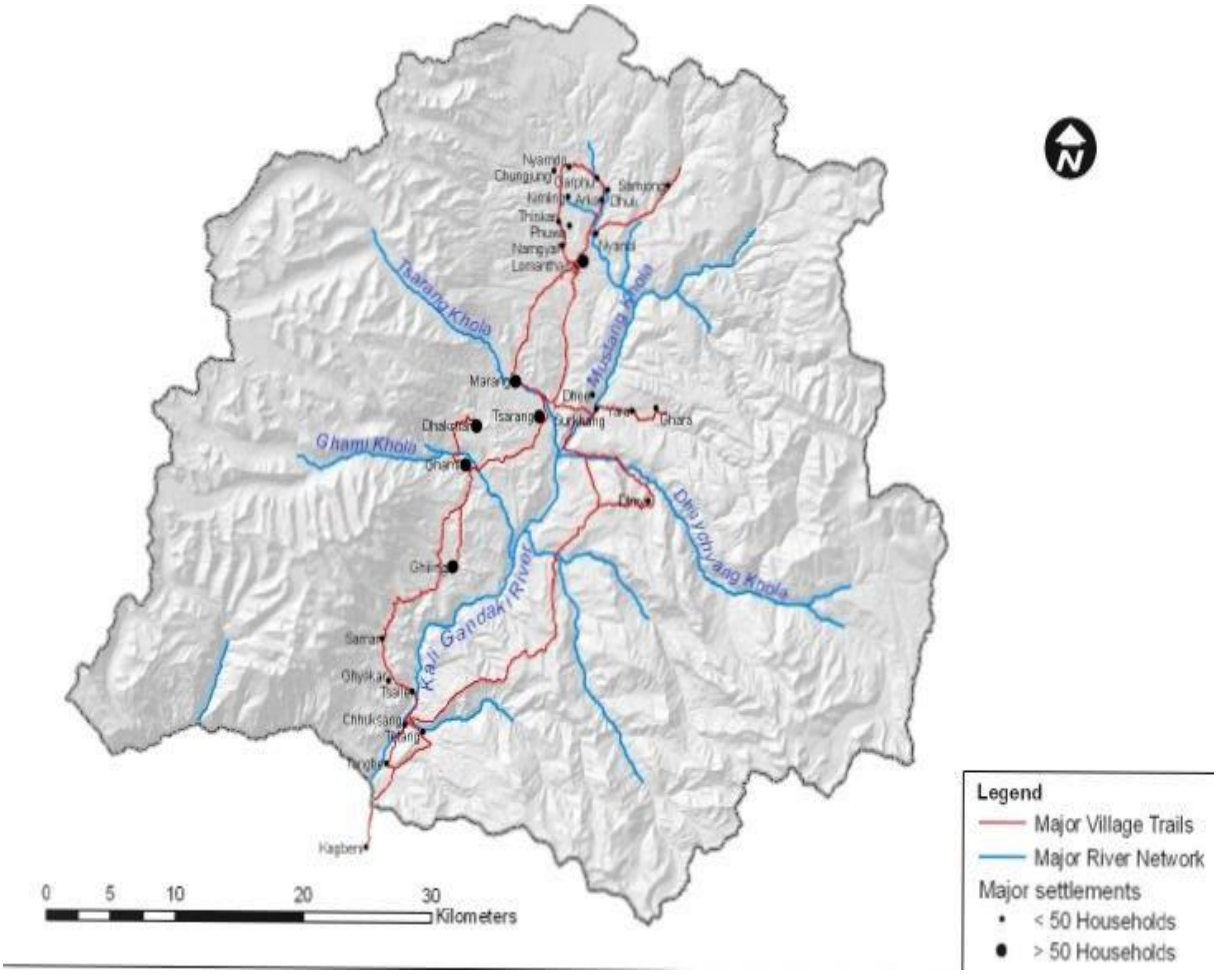


Figure 3.12. Major settlements, village trails and River network in Upper Mustang (Source: NTNC/ACAP, 2008)

3.3.2 Climate

The climate is semi-arid cold with an average day temperature of 10°C in winter months to 26°C in summer months. The night temperature in winter months drops below -10°C. Being under the rain shadow region of two giant mountains, Annapurna (8,091 m a.s.l.) and Dhaulagiri (8,167 m a.s.l.), the Upper Mustang region receives only 150 - 270 mm of rainfall annually (Figure 3.13) (Fort, 2015; Department of Hydrology and Meteorology, 2017). Most of the rainfall occurs during Monsoon (June – September). Between November to March precipitation falls as snow, making up more than half of the total precipitation (Chetri & Gurung, 2004; Paudel & Andersen,

2010; Fort, 2015). During winter, the region becomes isolated from the lower Mustang region as the roads are blocked with heavy snowfall (Pokharel, 2009).

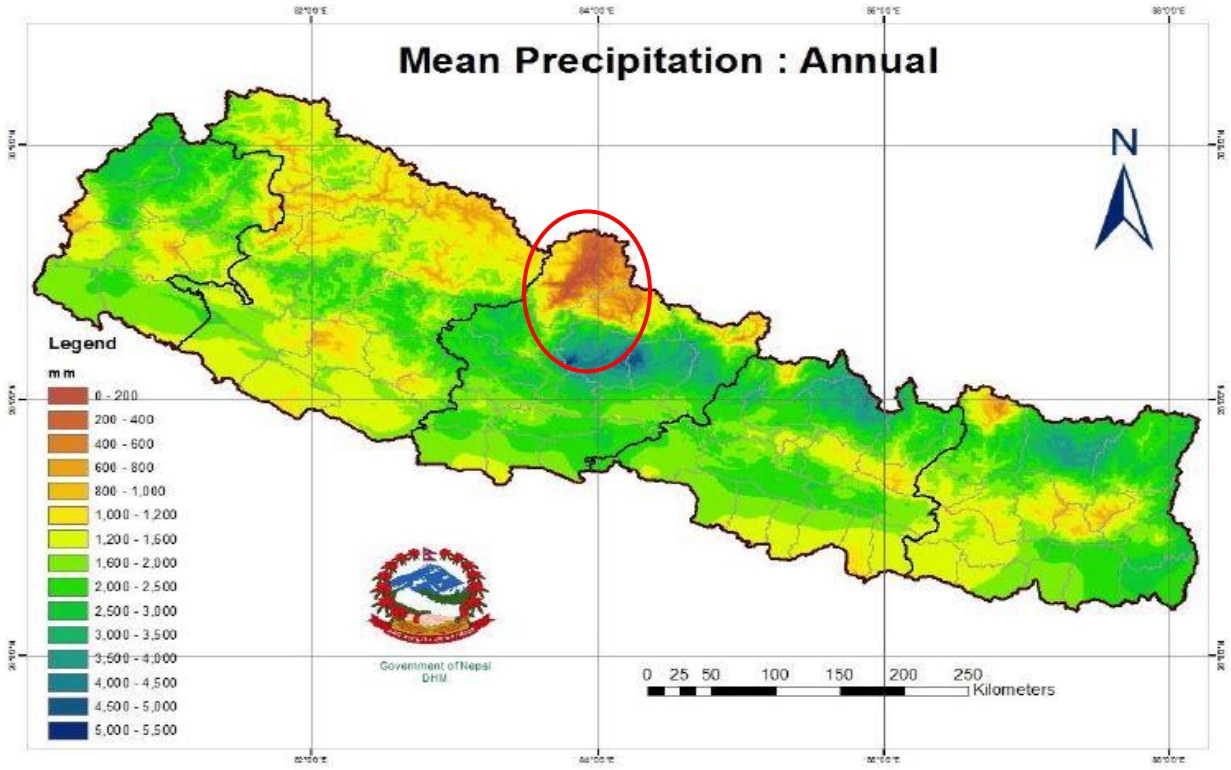


Figure 3.13. Map of mean annual precipitation in Nepal with the Upper Mustang region in a red circle (Source: Nepal Hydrological and Meteorological Research Centre and Consultancy, 2015)

The Upper Mustang region is also characterized by the constant wind pattern and intense sunlight for most of the year (Dhungel, 2002; Tulachan, 2003; Baumann, 2004; Pokharel, 2009; ACAP, 2010). The high solar radiation quickly warms the Tibetan plateau, creating low air pressure leading to the strong wind blow, especially in the late morning and afternoon (Tulachan, 2003). As a result soil erosion is prominent in the region (Pokharel, 2009; Fort, 2015). Strong wind pattern, low rainfall, and intense sunlight make this region a very harsh semi-arid region with a lunar-like rugged landscape that is barren, stark, and extremely fragile (Dhungel, 2002; Tulachan, 2003; ACAP, 2010).

3.3.3 The People and Culture

The Upper Mustang region is inhabited by the Lhoba (or Lho-pa) people - Lhoba refers to "southerners" or "the people of the south" in Tibet (Figure 3.14). They are culturally, linguistically, and ethnically similar to those of neighboring Tibet region (Fürer-Haimendorf, 1975; Jackson, 1984; Bista & Heide, 1997; Dhungel, 2002; Tulachan, 2003). People speak Tibetan dialects, practice Tibetan Buddhism, and often times identify themselves as "Historically Tibetan, but politically Nepali" (Shackley, 1996). The Lhoba people are traditionally traders, merchants who controlled the trade route along the Kaligandaki valley which was once a major trade route between Tibet, Nepal, and India, especially for salt (Shackley, 1994; Dhungel, 2002). The trade route operated until China's annexation of Tibet in 1959 (Dhungel, 2002; Tulachan, 2003).

Figure 3.14. Local people during a festival in Upper Mustang (Date: July 2018, Source: Author)

Lhoba people in the Upper Mustang region are socially stratified into three groups: *Kutak, Showa, and Righin* (https://hisnepal.org/index.php/lhowa-people-lowa-lhoba-lhowa-loba). The highest-ranked "*Kutak"* sometimes referred to as "*Bista*" as their surname are noble class. They

constitute the Royal family and are mainly concentrated around the town of Lo-Manthang with very few populations. The second group is "*Showa"* who belong to the commoner class and are referred to as Gurung. They constitute the majority of the population in Upper Mustang. The third group called *"Righin"* are the lowest in social status. They use Bishwokarma or Bika as their surnames (https://hisnepal.org/index.php/lhowa-people-lowa-lhoba-lhowa-loba).

3.3.4 Livelihoods

Given the harsh socio-ecological environment of Upper Mustang, people practice various livelihood strategies for meeting their sustenance needs (Jackson, 1984; Craig, 1996; Tulachan, 2003). The major livelihood activities of the Lhoba people include agriculture, animal husbandry, and trading. People have been practicing such kinds of livelihood activities over centuries and they are still in practice today. Moreover, these three major livelihood activities are completely interlinked and do not function independently from each other (Jackson, 1984; Basnet, 2007). Additionally, tourism is another livelihood activity practiced by local people and is relatively new as it only started in 1992 when the Upper Mustang region opened to the outside world (Shackley, 1994, 1995).

Agriculture has always been a major livelihood activity in the region (Figure 3.15 & 3.16). However, the production varies from village to village and even household to household in a village (Basnet, 2007). Further, the production is very limited due to the availability of limited cultivated land, lack of water for irrigation and a very short growing season (Jackson, 1984; ACAP, 2010). There is only one growing season in which people plant crops in late winter (February – March) and harvest in late fall (October) (Craig, 1996). Naked barley, wheat, buckwheat, pea, and potato are the major agricultural produce in the region. In recent years, local people have also started cultivating green vegetables such as cauliflower, cabbage, onion, radish, carrots, beans and

green leafy vegetables with the financial and technical help from various organizations like ACAP, and CARE Nepal (Basnet, 2007; Pokharel, 2009; ACAP, 2010).

Figure 3.15. Buckwheat in full bloom on farmland in Ghami (Date: August 2014, Source: Author)

Figure 3.16. Local people working on farmland in Yara (Date: June 2018, Source: Author)

People also grow fruits such as apple, and apricot, mostly in the lower elevation region. It has been said that climate change has allowed for the cultivation of vegetables and fruit, which could not be produced previously in the region (Pokhrel, 2018). Although agriculture is of major importance to the region, it is by itself inadequate to support the local livelihoods (Tulachan, 2003).

Animal husbandry (Figure 3.17) is another major livelihood activity in the region regarded as an important source of local wealth (Jackson, 1984). Moreover, animal husbandry is integral to agriculture particularly as a source of fertilizer, for plowing, threshing, and for hauling (Tulachan, 2003; Basnet, 2007). Cattle dungs and goat pellets constitute the major source of fuel for heating houses and cooking meals. Sheep, goats, cattle, Yak, Dzopa, and horses are animals that are usually kept in the region.

Figure 3.17. Goats and sheep gathering after returning from grazing in nearby rangelands in Samzong (Date: July 2018, Source: Author)

Horses are an important part of the culture and landscape in the Upper Mustang region. They symbolize wealth, status and authority (Tulachan, 2003; Basnet, 2007) and are mainly used for transportation purposes (Figure 3.18). A century-old, horse racing festival called *"Yartung"* is

held each year on the eighth month of the Tibetan calendar (August in English calendar) in various villages of the Upper Mustang region. The *"Yartung"* festival is three days of festivities celebrating the end of a healthy crop season. It is also a way of showcasing strength and courage while competing on horses between villagers.

Figure 3.18. Local people riding horses on their way from Yara as a means of transportation (Date: June 2018, Source: Author)

Dzopa (crossbreed of yak and cattle) are kept as draft animals to plow the farmlands (Figure 3.19) and carrying goods. Cattles are kept for mostly milking purposes. Sheep and goats are other common animals kept mainly for the purpose of meat, milk, and wool. Every year, large flocks of goats and sheep are exported to the southern cities of Nepal for sale during Hindu festivals like Dashain, and Tihar. A total of 13,000 sheep and 9,000 goats were sold making NRS. 270 million (270,000 USD) in the year of 2017 (Gautam, 2017). Similarly, Yaks are kept for milk, butter, cheese, and meat.

Figure 3.19. Dzopas coupled with a primitive wooden plow to furrow the farmland in Samzong (Date: July 2018, Source: Author)

Historically, large herds of yak and flocks of goats and sheep were kept in the region. In winter, when the grass was not enough on the rangelands in Upper Mustang, the herds were taken to the Tibetan rangelands across the border (Jackson, 1984). This was the customary practice for centuries. However, the grazing on the Tibetan side greatly diminished after China's annexation of Tibet in 1959 and the century-long practice has been completely forbidden now (Jackson, 1984; Tulachan, 2003). While agriculture and animal husbandry constitute important livelihoods, they are inadequate to meet the subsistence needs of the local people in the region (Jackson, 1984; Tulachan, 2003).

Traditionally, trade played a major role in the livelihoods for centuries which lasted until the mid-20th century. The route along the Kaligandaki River through Upper Mustang was an important route for Trans-Himalayan trading between western Tibet, Nepal, and India (Jackson, 1984; Craig, 1996; Tulachan, 2003). The trading mainly involved the exchange of Tibetan salt,

minerals, and animal products and manufactured goods and grains from the south (Jackson, 1984). Trading came to a virtual halt in 1959 after China invaded Tibet (Tulachan, 2003). It was, however, resumed after two years but under completely different circumstances with the Chinese authorities enforcing time and location restrictions. The trading practice completely stopped eventually as the Tibetan independence movement uprising activity started led by a rebellion group called *Khampa guerrilla* centered in the Upper Mustang region (Tulachan, 2003).

Currently, the border is again opened but only twice in a year for semi-annual trans-border trade fair which is held in the Tibet region (about 13 km inside Tibet from the border) for a local trader from Nepal and Tibet (Figure 3.20). During the trade fair, local merchants from Nepal export and sell medicinal plants, handicrafts, wool, and farm products while import various essential goods such as household utensils, electronic appliances, clothes and livestock such as goats, sheep, and horses from Tibetan merchants (Figure 3.21). The government of Nepal has taken initiatives to open the Kora la border as China agreed on opening the six border crossings (one of them is Kora la border in Upper Mustang) officially in 2012 (Tripathi, 2016). Now, the constructions of infrastructure building like highways and customs departments for the establishment of a border outpost are underway.

Winter migration is another major livelihood strategy for local people. After harvesting crops in October, people migrate temporally to the southern cities (Pokhara, Kathmandu) of Nepal and even to India (Dehradun, Assam, Ludhiana, Delhi, and Banaras) for the purpose of trading particularly textiles, and *Jimbu*, a seasonal herb mainly used to flavor vegetables, pickles and meat (Basnet, 2007; Pokharel, 2009). Winter migration not only helps them to support their livelihood by means of cash and commodities but also helps local people avoid the cold winter.

Figure 3.20. Nepalese and Tibetan merchants with their stalls during Trans-border trade fair in Tibet (Date: July 2018, Source: Author)

Figure 3.21. A Tibetan shop stall during trans-border trade in Tibet (Date: July 2018, Source: Author)

Tourism has grown as a major livelihood activity for local people as the Upper Mustang region opened to foreigners in 1992 (Gurung & DeCoursey, 2000; Dhungel, 2002; Tulachan,

2003). People engage in tourism by operating lodges (Figure 3.22) and camping sites, working as a guide, selling souvenirs of Tibetan origins and providing horse riding services. The area was opened as a semi-restricted region as such tourists are required to obtain a permit which costs 500 U.S. dollars for 10 days of stay, and for overstay, visitors are required to pay extra 50 U.S. dollars per day. Since its opening, about 60% of the revenue generated by tourism was assured for rural development and conservation to the local community (Gurung & DeCoursey, 2000).

Figure 3.22. A lodge locally constructed from stone and baked mud bricks in Surkhang (Date: June 2018, Source: Author)

Every year thousands of foreigners find a way to Upper Mustang to explore the spectacularly vast, semi-arid, and windswept corner of the Himalayan nation of Nepal. In 2013 a total of 3,344 people visited Upper Mustang, compared with 483 foreigners at the time of its opening in 1992 (Limbu, 2014). Although tourism had been a promising livelihood strategy, it has created a huge gap among people. Usually, the affluent and powerful people are the one receiving all the benefit because of their monopoly in the tourism business (Pokharel, 2009).

3.4 Yara; the Case Study Village

Yara is a small village located in the eastern part of the Upper Mustang region (Figure 3.23 & 3.24). It is situated at 29°5'43.23" N latitude and 83°59'58.43" E longitude at an elevation of 3650 m a.s.l. The village previously belonged to Surkhang village development committee (VDC) but now it belongs to Dalome rural municipality under a new administrative system of Nepal. It is situated on the right side of *Puyung Khola*; the local stream that flows by the village. There are a total of 22 households residing in the village currently. Houses are closely clustered in an area of 0.1 km^2. Gurung is the dominant ethnic group in this village, and the culture and religion (Buddhism) are similar in many aspects of Tibetan culture and tradition.

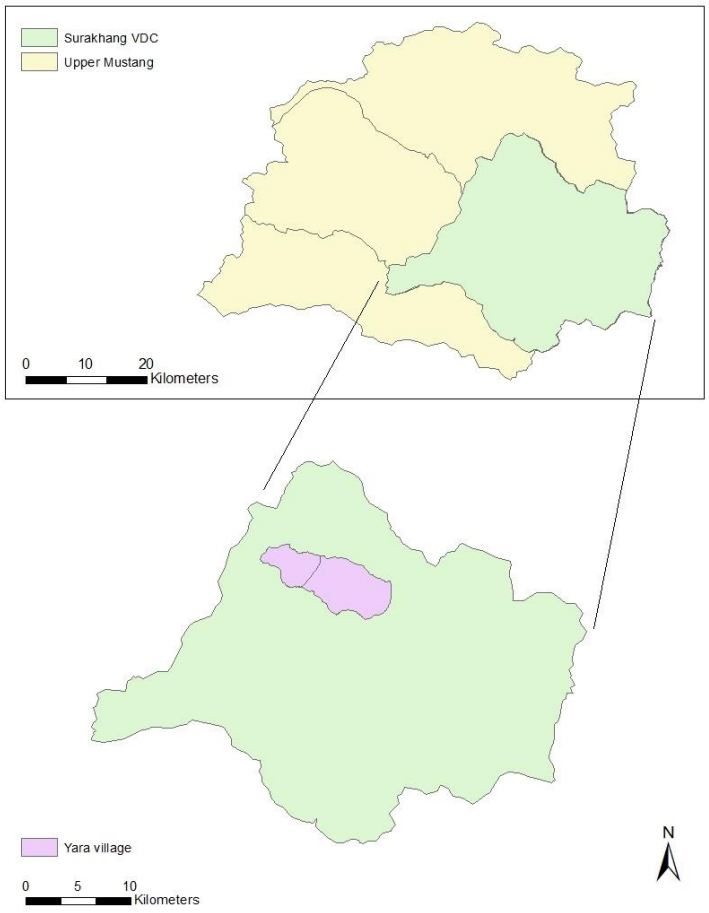


Figure 3.23. Location of Yara village within Surkhang VDC (old administrative structure) in Upper Mustang (Source: Author)

Figure 3.24. View of the central area of Yara village from the east situated in a geologically unstable section; a ditch dividing the village can be seen.

Table 3.1 provides information on Yara village. Total population is 100, among which 46 are male and 54 are female (Based on the fieldwork). Locals speak Tibetan as their mother tongue while Nepali is also spoken in the village. Locals are mainly involved in agriculture and animal husbandry. Besides, there are few households involved in tourism businesses.

Table 3.1. Summary of Yara village's sociodemographic information

S.N.	Variables	Data
1.	Total Number of Households	22
2.	Number of Inhabitants	100
3.	Male Population	46
4.	Female Population	54
5.	Language	Tibetan and Nepali
6.	Average Household Size	5
7.	Major Livelihood Activities	Agriculture, Livestock Rearing, Tourism, and Trading
8.	Crops	Wheat, Potato, and Vegetables
9.	Livestock	Sheep, Goat, Cow, Horse, and Dzopa (Hybrid of cow and yak)

The village is situated on a fragile geological structure mainly based on limestone and marly limestone outcrops affected by a huge deep-seated gravitational slope deformation (Bernet et al., 2012). As a result, the settlement area and surrounding farmlands are prone to rotational and translational landslides. Yara is accessible by an earthen road which connects it to Tsarang village (the nearest village) and to other villages in Upper Mustang and to Jomsom in the south.

3.5 Annapurna Conservation Area and the Annapurna Conservation Area Project

Established in 1986, the Annapurna Conservation Area (ACA) (Figure 3.25) is the first and largest Conservation Area in Nepal (KMTNC, 1996). The conservation area expanses across five districts of Nepal, covering the entire Mustang district (our study area) and certain regions in Manang, Kaski, Myagdi and Lamjung districts. It covers an area of 7,629 sq.km and is home to

over 100,000 people belonging to diverse ethnic, cultural, and linguistic groups (NTNC Profile, 2009; NTNC, 2017).

This region's cultural diversity is equally rivaled by its biodiversity (Allard, 1995; Thakali, 1995). Stretching from the subtropical lowlands and lush temperate rhododendron forest in the south to a dry alpine steppe environment in the north, the Annapurna Conservation Area is a treasure house for 1,226 species of flowering plants, 105 mammals, 518 birds, 40 reptiles and 23 amphibians (NTNC, 2017). It is home to the world's deepest river gorge - the Kaligandaki Gorge and Tilicho Lake (4,919 m a.s.l.), the world's highest altitude fresh-water lake (KMTNC, 1996).

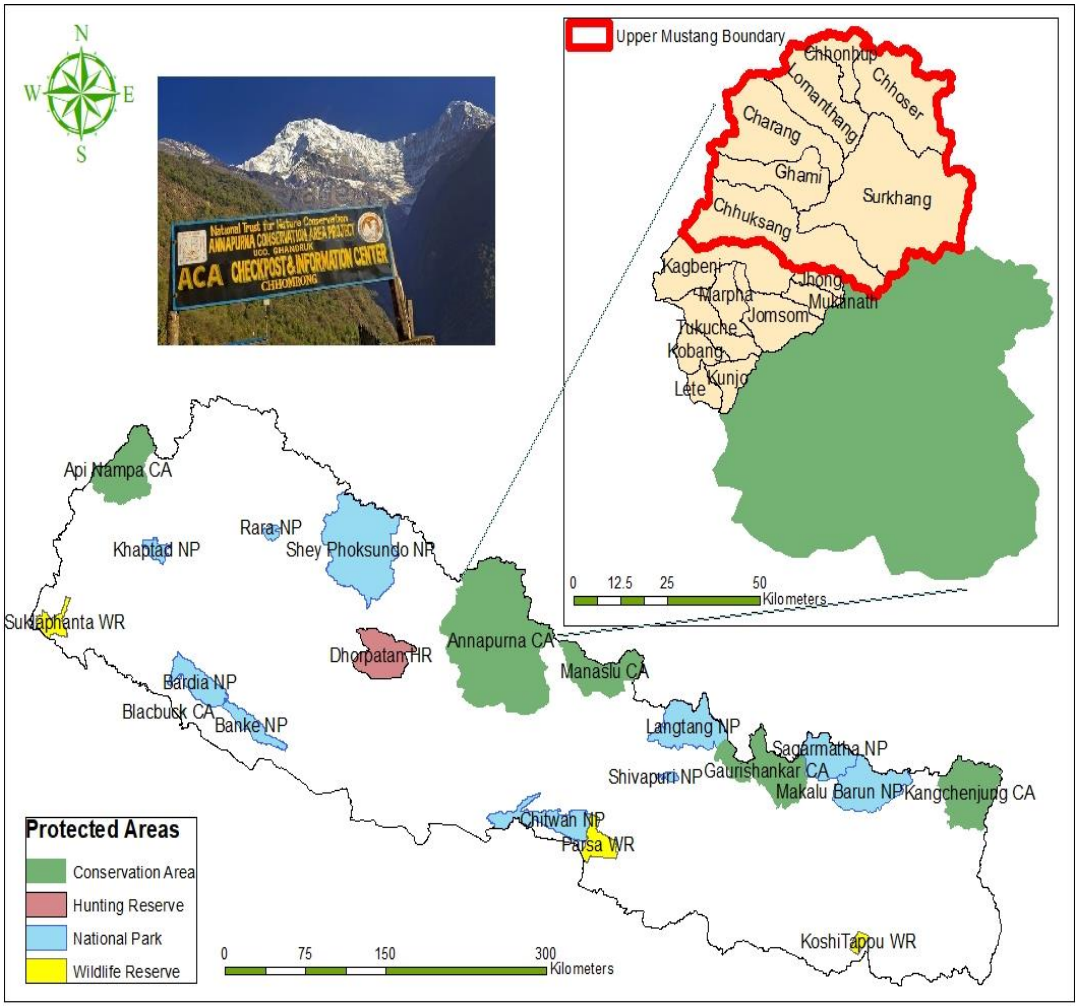


Figure 3.25. Map of Annapurna Conservation Area (ACA), Upper Mustang and other protected areas of Nepal (Source: Author)

ACA's natural and cultural attractions have made it the country's most popular trekking destination, drawing most of the tourists that come to Nepal every year. According to the ACAP's statistical record, a total of 158,579 foreign tourists visited the Annapurna region in 2017, which is 38.8% higher than the figures of 2016 (https://www.tourismmail.com/annapurna-region-sees-record-number-of-tourists-in-2017). As such Tourism in the region has become one of the largest contributions to the local economy over the years. Figure 3.26 shows the number of tourist arrival in ACA region from 1989 to 2018.

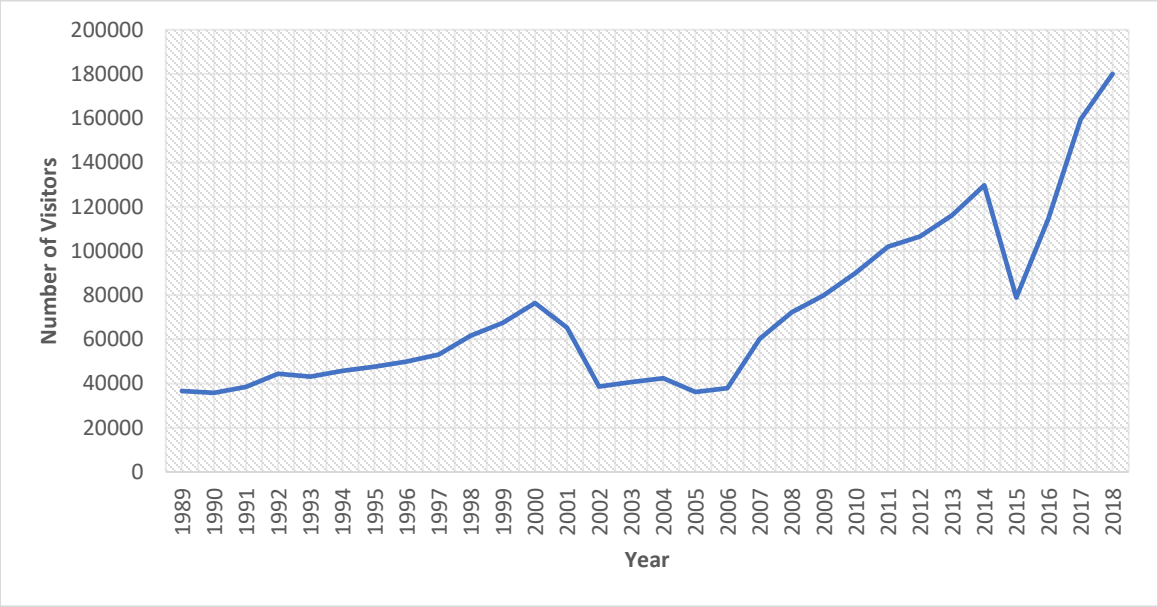


Figure 3.26. Record of the annual number of visitors in Annapurna Conservation Area (1989 - 2018) (Source: ACAP)

ACA is governed by the Annapurna Conservation Area Project (ACAP) since its gazettement in 1992 under the guidance of the National Trust for Nature Conservation (NTNC), Nepal's leading autonomous non-profit, non-governmental environmental organization (Thakali, 1995). It was in ACA where the Integrated Conservation and Development Program (ICDP) model of conservation was developed and tested by NTNC. The model is now widely accepted and implemented at both national and international levels (NTNC, 2017).

Three basic principles guide activities of the Annapurna Conservation Area Project: sustainability, people's participation and Lami (catalyst) role (Thakali, 1995). Following these principles, ACAP works on a grassroots philosophy in which local communities are involved in all aspects of conservation and in all stages of development: from planning to implementation and monitoring (Nepal, 1997; NTNC, 2017). In practice, ACAP plays a catalytic role in providing resources to ensure sustainable livelihoods of local communities.

In the grassroots level, Conservation Area Management Committee (CAMC) is formed to provide the authority to mobilize resources and ensure wider participation of the local people in all the conservation and development programs (Baral et al., 2007; NTNC Profile, 2009). As such, by recognizing the importance of local participation, ACAP has been integrating natural resource management with tourism management, development of alternative energy resources, heritage conservations and various community development programs such as empowering local people by providing appropriate skills, knowledge, technical and financial assistance and women development programs (Thakali, 1995; NTNC, 2017). In particular, ACAP focuses mainly on the Conservation and Extension Program (CEEP), which aims to promote awareness of conservation among local people, visitors, and all parts of ACA. ACAP considers CEEP as the cornerstone of the project with the ethical belief that only education can change people's attitude towards conservation and sustainable community development (NTNC Profile, 2009). Moreover, ACAP has been working with the following objectives,

- Conserve ACA's natural resources for the benefit of current and future generations.
- Bring sustainable social and economic development to the local communities.
- Develop tourism with minimum adverse effects on the natural, socio-cultural and economic environment.

ACAP collects a certain amount of money (NRS. 2000 = 17.94 U.S. dollars as of 19th April 2019) for each foreign visitor as an entry fee. The revenue generated through entry fees is the largest financial resource that ACAP reports are being reinvested in the form of the annual budget in the natural resources conservation and sustainable community development of the region (Schuett et al., 2016; NTNC, 2017).

Through ACAP, the NTNC has carried out its mission to promote conservation and prosperity of the Annapurna region, its resources and the population over more than three decades (NTNC Profile, 2009). By implementing various conservation and community development programs, NTNC is focused on the building of local capabilities at the individual and institutional levels and on inspiring people towards sustainable development while not impeding the environment. However, NTNC believes that the local people themselves will eventually have to manage those areas to achieve the ultimate goal of complete local governance in ACA with minimal intervention from the government and other institutions (NTNC Profile, 2009).

CHAPTER 4: HARDSHIP IN RURAL MOUNTAIN LIVELIHOODS; FINDINGS FROM YARA VILLAGE

This chapter provides a description of different livelihood arrangements and factors that support or hinder the development of sustainable practices of rural households in Yara village; the sustainable rural livelihood framework (DFID, 1999) is utilized to help organize and interpret the meanings constructed by study participants that emerged from the open ended-ongoing qualitative data analysis process. In doing so, this section addresses our research objective one which is intended in gaining an in-depth understanding of local people's perception of factors that lead to livelihood vulnerability and adaptation strategies to achieve sustainable livelihoods. Hence, the findings emerged from the responses of participants, letting their voices be heard. The framework has been employed to group emergent codes into categories following the five components of the sustainable rural livelihoods model. These components, as described in chapter 1, are (1) Livelihood Assets, (2) Vulnerability (3) Transforming Structures and Processes, (4) Livelihood Activities and Strategies, and (5) Livelihood Outcomes. Each component, as applied to the Yara case, is described in detail below.

4.1 Livelihood Assets

This category includes the resources available for local people to derive livelihood outcomes such as improved food security, higher income, greater well-being, reduced vulnerability, and improved environmental sustainability (DFID, 1999). These assets are categorized as five capitals: (1) Human Capital, (2) Social Capital, (3) Natural Capital, (4) Physical Capital, and (5) Financial Capital. These capitals are the foundation of the household's livelihood activities and strategies, and hence, determine livelihood outcomes. However, the frequency and conditions under which different households in Yara access these five livelihood capitals are

determined by multiple factors, hence, resulting in different livelihood outcomes and ability to respond to changes.

4.1.1 Human Capital

Human capital mainly comprises labor capacity, education level, health conditions, and skills that support livelihoods. In Yara, the average family size is 4.5 members. In terms of education, nearly 54% of interviewees had some level of formal schooling; however, all of them had attained only elementary schooling. About 46% of participants from Yara reported being illiterate.

When asked, most of the villagers mentioned having sent their children to Lomanthang (the nearest village form Yara), Jomsom (the district headquarters) for secondary level schooling and southern cities like Pokhara or Kathmandu (the capital city of Nepal) for higher studies. It was because of the limited opportunity of education in the village; up to the primary level. While conducting the fieldwork in June 2018, there were only four students in the school (Figure 4.1). Villagers also mentioned their concern about having a better quality of education and opportunity of higher education as the major reason for sending kids to places outside of their village. Additionally, all respondents said that their children's education has been mostly supported by sponsorship from foreigners. In the following quote, a female respondent (30 – 40 years old) mentioned about the donors who have been supporting the education of her siblings. According to her, foreigners sponsor the entire cost of education including accommodation and food and they are mostly from Switzerland.

> *Bhai baini haru ko padhai ko sabai sponsorship chha. Khane basne, padhai ko lagi sabai bidesi donor le padaidinchha.Dherai jasto switzerland bata donor haru le sahayog garchha ra padne khane sabai byawastha garidinchha. (Household Interview, 06/18/2018)*

My brothers and sister are all studying on sponsorship. Sponsors provide financial support for their education as well as for their food and accommodation. Sponsors are mostly from Switzerland. (Translation, 06/30/2019)

Figure 4.1. During a class at school in Yara (Date: June 2018, Source: Author)

Even though education is considered to be important globally, local people in Yara had not recognized as a valuable asset. In the past, people were only provided elementary level education and did not consider higher education to be worth the investment for their children. Most of the parents preferred their children assisting them in their household chores and responsibilities. The following quote is by a female respondent in her 30s. She shared her childhood experience while emphasizing not being able to continue beyond elementary education as she had responsibilities to assume as the eldest child in her family.

Ma ta estai ho sano dekhi ba aama le ramro sanga padaena. Jamma 4 class samma matra padyo ei yara ko school ma. Tespachi ba aama le ni khasai wasta garnuvaena ra maile pani padne sochena. Ani padai chutyo tespachhi. Savbanda jetho ho ma, bhai baini lai heryo, ghar ma kam sabai afai garnupartyo ani

> *tesapchhi padai rokiyo. Hami ali garib pani thiyo tetibela. aruko kam ma janthyo bela bela ma. (Household interview, 06/19/2018)*
>
> *Well, my parents did not educate me well. I only have 4th-grade education which I did from the primary school in our village. After 4th grade, my parents never sent me back to school and I also stopped thinking about going back to school. There my schooling ended. I am the eldest child! I had to look after my siblings and had to do most of the household chores. Our household condition was also poor at that time. So, we also used to do labor work occasionally. (Translation, 06/30/2019)*

Various organizations such as ACAP, CARE Nepal and government offices are present in the region while providing various training to local people, such as irrigation canal maintenance training, green vegetable plantation training, and adult education to teach community members how to read and write, etc. The following are quotes from a female (50 - 60 years old) and a male (30 - 40 years old) resident who talked about the contribution of CARE Nepal to the community, and the types of training being provided to locals. ACAP is still in operation whereas CARE Nepal project only worked in the village for a few years.

> *Sabainvanda dherai sahayog the CareNepal le garekothyo. Khanepani tatha sichai ko marmat garna sajilo ko lagi Care Nepal le gaule harulai training pani dieko thiyo. (Household interview, 06/03/2019)*
>
> *CARE Nepal helped a lot to the community. For the maintenance of drinking and irrigation water they even provided training to the local people. (Translation, 06/29/2019)*
>
> *Pachi ACAP ayo, CARE Nepal ayo. Pachhi esto office haru ayo. Rati school padaune ayo ra hami janthyo padhna ei ko master le padauthyo 2 parsa aghi samma.Natra ka thulo manchhe haru padna janchha ra. Tesai gari CARE Nepal le pani praudh sikchhya dieko thiyo. (Household interview, 06/12/2018)*
>
> *Later here ACAP and CARE Nepal arrived. They started providing adult education to local people. School also provided this facility to us until 2 years ago. CARE Nepal also provided adult education. (Translation, 06/29/2019)*

In the case of the labor force, parents are the only source of labor available all year round in the village. Children are sent to schools in cities and, as a result, they are absent in the village for most of the time in a year. However, they often visit the home during vacations. They help

their parents in various household works such as rearing livestock, cooking, collecting grass, running hotels, etc.

In Yara, education levels are generally low but it can be seen that with the growing awareness among people about the importance of education, it can be a great asset in future as most of the households are educating their children while sending them far away from in search of quality education. Additionally, with higher education, there are possibilities of development of advanced skills and technologies that could help to make livelihood sustainable.

4.1.2 Social Capital

The greatest social capital is the local norms and rules with which locals are socially bonded with each other for many generations. Buddhism and Tibetan culture are deeply rooted in the community guiding the way of life of local people in the village. Religiously, gumba (*monastery*) plays a vital role in local people's livelihood. Local people's life cycle beginning from birth to death revolves around the belief and worshipping in monasteries.

Another form of capital is the traditional leadership system in Yara. A Ghenpa (Mukhiya in Nepali) is selected as the head person of the village for a year or sometime two years. Currently, a female has occupied the post. She is responsible for the decision-making process in regulating communal rules to utilize common pool resources, settling disputes, gathering assemblies and organizing religious ceremonies (Tulachan, 2003; Bernet et al., 2012).

Besides, trust and local social networks among households play a significant role in shaping the livelihoods of local people. Mutual help among households in farm work as labor work, sharing of resources such as irrigation water, drinking water are common practice in the village.

As I looked closely, social bonding within a household was also evident among members in every household in Yara. Even in just a short period of stay in the community, I was able to observe the unity and collaborative effort of each household member to make their livelihoods. In the following quote, one of the key informants and a renowned traveler and writer from Austria shares his experience of seeing a strong bond among household members of the village head; which he has been observing since 1992 as he makes his trips to the village every year. He asserts the bondage and the origins are even powerful to the present years even over the years.

> *I am still surprised especially if I see now particularly this family where I visit every year. The young people, the daughters, sons have sacrificed a lot. They still support the family, their mother. And this is amazing. And this you can see how strong the roots are. Of course, in wintertime, it is normal that you are not staying here. What should they do here? There is no way of income. They go to Kathmandu, Pokhara. This is normal. But still, they come back and maintain the family and living. (Key informant interview, 06/14/2018)*

This shows that people have been sharing labor within a household and among neighboring households for a long time. As such, it has helped locals to collectively achieve livelihood goals.

4.1.3 Natural Capital

Natural capital comprises natural resources available in the region, including land for farming and grazing, and water resources. One of the major resources is the available land for agriculture. Out of the 22 households present in Yara in 2018, 14 own farmlands; while the remaining eight households do not own any piece of farmland as they are mostly poorer households. The total area of cultivated farmland available is 0.1 km^2 located near the village.

The water for irrigation is solely dependent on the nearby river called *Puyung Khola (river)*. The river is drained by glaciated water and accumulated water from snowfall in winter and

summer rainfall. The drainage area of *Puyung Khola* is measured roughly 51 km^2 (Bernet et al., 2012).

Available rangelands are limited in area and mostly above 4000 m a.s.l (Figure 4.2). These rangelands are 3-5 hours away from the village to a full day walk depending upon the location. Sustainable use of these resources is key for the local people given the very scarce amount of grassland available. However, according to local people, grasslands are degrading due to decline in snowfall and rainfall. Due to lack of grass in rangelands, local people reported that they feed livestock with corn, wheat, grass brought from neighboring villages and southern cities such as Tsarang, Marang, Lomanthang, and Pokhara, etc. According to local people, the current market rate is Nepalese Rupees (NRS). 30/kg for dried grass and NRS. 50/kg for green grass.

Figure 4.2. Rangelands in Yara (Date: June 2018, Source: Author)

Natural forest is completely absent in Yara village and the surrounding lands. The only available trees are through the plantation. Poplar (*Populus ciliate*) locally known as *Bhote pipal* is

planted along the streams or irrigation canals and on the farmlands. Timber from the tree is used for the building of houses, mostly the trunks for making beams and for roofing. Branches can be used as firewood. Most of the plantation is now supported by ACAP. According to local people, CARE Nepal also helped in plantation and in building a wall around the plantation fields.

4.1.4 Physical Capital; Infrastructure and Services

There are major constraints in terms of physical capital in Yara. There is no electricity provided by the government or private company. Locals rely on solar power to light up the rooms and to power electronic devices such as televisions, radios, and mobile phones. There is no health services facility in the village; the nearest available health post is in Surkhang village, around two hours walking distance from Yara. The available institutions and facilities found at the village are a primary school, a community hall, a gumba (monastery), a religious rest house for pilgrims, and a solar-powered mill. Road network connecting Yara to nearest village Tsarang and the headquarters is a recent development in the region, which has brought many opportunities for locals, such as facilitating travel and the transporting of goods for household consumption and for markets.

According to the local people, drinking water was first provided by an organization called CARE Nepal in 1994. The organization helped to install five water taps in the village initially (Figure). However, as of June 2018, there is only one working water tap in the village (Figure 4.3). Other four are not in use as the water dried in the village. An elderly female respondent from the village mentioned how CARE Nepal helped build taps and how it helped local people with drinking water which they previously used to bring from the nearby river. She also mentioned the

reliance of local people on the working water tap while describing the current condition of other taps.

> *Paila hamile khanepani tala khola bata laune garthyo. Pachi CareNepal aera khanepaniko byawastha garidiyo 2051 sal ma. Hamilai 5 wata dhara banaidiyo khanepaniko. 6- 7 barsa sama ramro sanga pani authyo. Tara aile paani ko dherai samasya chha. (Household interview, 06/03/2018)*
>
> *We used to fetch drinking water from the river in the past. In 2051 BS (1994 AD), CARE Nepal started working in our village. They built 5 water taps for us. It worked very well for 6-7 years as there was enough water. But after that water dried and it stopped working properly. Now we have been facing severe drinking water problem. (Translation, 06/30/2019)*

Figure 4.3. An elderly woman fetching water at the only working tap in Yara (Date: June 2018, Source: Author)

The houses in Yara are generally built with available material from the area such as locally made mud bricks, Poplar timbers, stones, etc (Figure 4.4). Houses are generally compact with the main entrance leading to the kitchen, and other available rooms (storeroom, bedrooms). More than half of the houses in Yara are two-storied. Roofs are generally flattened with local mud and small windows are made in the middle of the roof to be able to utilize the sunlight given lack of electricity.

Figure 4.4. Houses in Yara along with the motor road (Date: June 2018, Source: Author)

According to local people, the geology of Yara is extremely fragile with continuously moving soil. Many people have abandoned their old houses, while others are still affected by the fragile soil phenomenon. The following quote by a female respondent (30-40 years old) emphasizes the fragility of soil in the village. She also mentioned the problem with leakage of irrigated water in farmland.

Ani yara ko jaga nai naramro chha. bhasine jagga chha. Pari tyo khet ma pani paani halyo vane sabai bhasera paani bhitra janchha. Ya waari ko khet haru pani testai chha bhasinchha. Aba eta gau tira ni bhasidai audai chha. Yara gau ko mato ramro chhaina. Yo pani euta thulo samasya ho. aba dhey, tangya tira ghar haru 3 4 pusta sama hunchha re tara yara ma ta ghar 1 pusta mai bhatkera janchha. (Household interview, 06/18/2018)

…similarly, soil is of very bad quality in Yara. Ground frequently gets cracked here. When we irrigate farmland all the water goes into the ground because of the seepage problem. Ground cracking is shifting towards the village slowly. Soil is really bad here. This is also a big problem for the villagers. Well, in Dhey and Tangya, houses last for 3 to 4 generations whereas in Yara houses even do not last for 1 generation. It gets destroyed in just 1 generation. (Translation, 06/30/2019)

4.1.5 Financial Capital

As reported by the locals, agriculture, animal husbandry, and trading are the major income-generating activities (Table 4.1). Although participants reported agriculture to be a major livelihood activity, it only contributes marginally to the overall income of a household. Livestock, on the other hand, is an important source of income as it serves as a liquid asset; livestock can be sold for cash when needed to support household expenses. Some of the households kept a large number of livestock especially goats and sheep for selling them in the market.

Table 4.1 lists the details on livestock numbers and various income generation activities practiced by locals. Based on the fieldwork in June 2018, there were 1775 goats/sheep, 46 cows, and 29 horses recorded in Yara. Five households are engaged in animal husbandry only. Whereas a total of eight households are involved in both animal husbandry and agriculture. Seven households participate in trade; in the southern towns of Nepal during winter migration. Three locals are employed in foreign countries. Six households generate seasonal income through horse rental services.

Table 4.1. Number of livestock owned by households and their major income resources (Based on Field data)

Household	Number of goats and/or sheep	Number of cows	Number of horses	Income generation activities
1.	125	5	2	Animal husbandry; Agriculture Trading; Horse services
2.	150	3	2	Animal husbandry; Agriculture
3.	10	2	2	Agriculture
4.	150	1	1	Animal husbandry
5.	110	4	2	Agriculture; Animal husbandry
6.	125	5	3	Hotel; Horse service; Animal husbandry
7.	30	4	1	Hotel; Agriculture
8.	195	2	3	Hotel; Trading; Animal husbandry Horse services
9.	180	3	3	Animal husbandry; Horse services
10.	-	-	-	Trading; Wage labor
11.	-	-	-	Trading; Wage labor
12.	220	3	2	Trading; Animal husbandry; Agriculture
13.	50	2	1	Animal husbandry; Agriculture
14.	10	-	-	Wage labor
15.	100	5	2	Animal husbandry; Agriculture
16.	-	-	-	Wage labor
17.	-	-	-	Trading; Foreign employment
18.	20	2	1	Wage labor; Foreign employment
19.	110	3	2	Horse services; Animal husbandry
20.	190	2	2	Hotel; Animal husbandry; Agriculture; Horse services
21.	-	-	-	Wage labor
22.	-	-	-	Trading; Foreign employment
TOTAL	**1,775**	**46**	**29**	**12 households participate in animal husbandry, 9 in agriculture, 7 in trading, 6 in wage labor, 3 in foreign employment, and 4 run hotels**

Tourism is a recent form of income generation for local people, which started after the Upper Mustang region opened to foreigners in 1992. Since then, local people have participated in various tourism activities such as running hotels, working as guides and porters, providing horse services, among others. There are four households who run hotels in Yara village. They provide

lodging and food services to international and domestic tourists traveling to the region. Other households who owned horses reported that they generate income while providing horse services to international tourist who comes for trekking and to pilgrims traveling to the Holy Damodar Kunda (Lake) region for religious purposes. May, August, and October are most preferred months by foreigners to travel in the region. Pilgrims arrive at *Damodar Kunda* from June to August as these months are considered ideal with less cold weather. One male respondent (30 – 40 years old) explained how horses are used as a source of income generation while providing a means of transportation for visitors to the area.

> *Ghoda bata aile tei Damodar Kunda jane tirtha yatri lagera ali ali amdani huncha. Euta ghoda bata testai 7500 jati jyala linchau. Testai sardar ma ek barsa ma 5-6 choti sama ghoda damodar kunda jancha tirtha yatri liera. Tyo amdani le ghoda lai dana khuwana pugha. (Household interview, 06/16/2018)*
>
> *Horses are used as a means for providing transportation services to pilgrims. They help them to travel to holy Damodar Kunda (lake) and bring them back to the village. We charge 7500 rupees (USD 75) per person for the whole trip. This trip happens approximately 5-6 times every year. The money earned compensates the cost of food for horses with some profit. (Translation, 06/30/2019)*

4.2 Yara's Sources of Vulnerability

This category describes the factors that affect Yara village and its households in terms of risks and sources of vulnerability and hence addressing research question 2: What are the drivers of change that have influenced livelihoods? These drivers are broadly categorized as (1) Changing Climate Patterns, (2) Degradation of Natural Resources, (3) Socio-Cultural Changes, (4) Infrastructure Development, (5). Insect and Pest Outbreaks, and (6) Changes in Market System and Structure. Overall, every household felt there have been changes in the community throughout the years that have put at risk their livelihoods strategies and ways of life.

4.2.1 Changing Climate Pattern

Local people's perception of the climatic conditions is described in this category. The frequently mentioned concern is decreasing snowfall with unclear timing and uneven rainfall. Whereas locals are not sure about the village's temperature trend. Locals are nevertheless conscious of the wind occurrences in the village in recent years.

4.2.1.1 Decline and Shift in Timing of Snowfall

Snowfall plays a pivotal role in local people's livelihoods by regulating the water availability for rangelands and farmlands. Most of the water resources that provide for critical livelihood activities—agriculture, animal husbandry, drinking water—are dependent on seasonal snowfall and glaciers. Water gets accumulated from snow melts and comes down to the village in the form of a stream or river (Bernet et al., 2012). Those streams and rivers provide water for irrigating farmland.

All respondents mentioned observing/believing there is a decreasing trend of snowfall in the region. People were aware of the fact that they are not getting as much snow as they used to receive about 10 years ago. A female respondent (20-30 years old) recalls her past experience of heavy snowfall in the village and cleaning the snow-coated roof of her house.

> *Paila jado maina ma dherai hiu parthyo. ra hamilai safa garna parthyo. Tara aile yo sal ma ekdam kam hiu paryo ra tyo ni bilaera gayo. Hiu parne pani parne kam hudai gaecha. (Household interview, 06/03/2018)*
>
> *In past years, we used to get a lot of snow in winter. We had to remove heavy chunks of snow from our rooftops. But now, we receive very less snowfall. When it comes it is a lot less which diminishes right away. (Translation, 06/25/2019)*

A male respondent aged 30-40 recalls his experience of snowfall for the past three years while describing it as in a decreasing trend. He describes winter being full of snowfall in past years but less so more recently.

> *Paila ta hiu dherai parthyo. AIle ta hiu nai pardaina. 3 sal aghi ta hiud ma hiu mahinai pichhe paryo tara tespachhi aile aera yo sal ta hiu ekchoti ni parena. Pohor ek choti matra paryo. (Houehold interview, 06/08/2018)*
>
> *It used to snow before. It snowed every month in winter three years ago. But in the past two years, snowfall has become very rare. It snowed very less last year. This year, we did not get snow even once. (Translation, 06/25/2019)*

One of the male respondents (aged 40 - 50 years old) discussed the untimely snowfall in the village and emphasized the importance of timing and amount of snowfall for rangelands. He particularly mentioned the uncertainty in the timing of snowfall in the region as of the current pattern.

> *Hiu parne ko chai pohor parena yo sal pani parena tara parar chai besari hiu paryo. Paila paila hiu parthyo tara parar ta mainai pichhe paryo. Testo hiu pareko paila dekheko thena. Tara hiudo ma hiu ma hiu pareko ta teti ramro hudaina lek ko ghas ra tala khet ko pani lai teti ramro hudaina. Bela ma pareko hiu thik ho tara betime pareko hiu kam hudaina. (Household interview, 06/05/2018)*
>
> *We did not get snow this year and last year as well. But, the year before last year, we got a lot of snow almost every month in winter. I had not seen such an amount of snow before. Snowfall is appropriate if it falls in a controlled amount. Heavy and untimely snowfall are both harmful for rangelands and our livestock. (Translation, 06/25/2019)*

Another male respondent, who was in his mid-40s explained the connection between snowfall and snow cover in the mountain. He also mentioned snowfall contributing directly to local water resources as,

> *Ya maathi danda ma barkha ma ta hiu nai basdaina aile ta. Vanam na yo maina ma (june) mathi himal ma alikati kag jasto shape ko hiu dekhyo vane Yara gau lai paani ramro auchha vanne chalan chha. Hamile hamro bhasa ma "Yanghichi "Tara aile hiu sabai paglera gaecha himal ma. Hiud ma ramro hiu paryo vane bascha jamma vaera tara hiu parena vane khali nai hunchha. Yo sal ma hiu nai aaena. (Household interview, 06/08/2018)*
>
> *Nowadays snow does not last long in the mountains. It is believed that if we see a crow shaped like snow cover in the mountain, we get enough water for our village. We call it "Yaghichi" in our Tibetan language. But now, snow cover has diminished in mountains. Snow is accumulated in mountains only it snows well in winter. But, this year we did not receive any snowfall. (Translation, 06/21/2019)*

During key informant interviews with ACAP officials, the idea of unpredictability in terms of amount and timing of snow was also highlighted. Based on the experience of one of the key informants, he emphasized how snowfall is decreasing and shifting its timing as well. He described these changes as,

> *Yaha paila hijoko din ma samaya ma hiu parne, hiu paryapta matra ma parne garthyo. Tara aile chai hiu parne matra pani kam hudai gaeko ra parne time period pani farak hudai gaeko cha. Hiu ko pattern lagatar 3 barsa yata ko pattern herda chai timing shift vaera gai raakheko dekincha. Push magh ma hiu nai parna chodya cha vane Falgun, chait, baisakh ma hiu parna thaleko cha. (Household interview, 05/30/2018)*
>
> *It used to snow in good amount before. The timing was also perfect. But now, there is less snowfall as well as there is a change in the timing of snowfall. If we look at the pattern of snowfall in recent three years, we can see the shift in snowfall timing. Usually, snowfall occurs from December to February but, now it has shifted towards April-May. (Translation, 06/25/2019)*

Further, a female respondent in her 30s from Yara also felt the seasonal change in snowfall and said she has not seen snowfall in its actual time in recent years.

> *Khai espali hiu nai parena. Baisakh maina ma paryo ek patak tara tyo hiu parne time haina. Season nai kasto change vaechha aile. Hiu parne time ma pardaina. (Household interview, 06/18/2018)*
>
> *Well, we did not get snow this year. It snowed in April just once, but it is not the time for snowfall. Season has changed nowadays. It does not snow when it is supposed to be. (Translation, 06/29/2019)*

The remote sensing analysis of snow/ice cover (described detail in Chapter 5) also showed a declining trend over the past 19 years in the Upper Mustang region. Additionally, some previous studies (Paudel & Andersen, 2011; Mishra et al., 2014) also reported a decline in snow/ice cover in the mountains of the Upper Mustang region.

4.2.1.2 Too Little or Too Much Rainfall

In average, the Upper Mustang region receives only 200-270 mm of rainfall annually (Department of Hydrology and Meteorology, 2017). In recent years, rainfall has become even scarcer. As expressed during the interviews, local people were highly aware of the fact that they have been receiving less rainfall than before. Besides snowfall, summer rainfall has also a direct impact on vegetation in rangelands. An old female respondent (50 - 60 years old) described her perception about summer rainfall and how it has impacted grass growth in rangelands as,

> *Pahila aakash ko paani pani ramro parthyo. Paani parera ghas ramro hunthyo mathi lek ma ra khet wari pari pani. Tara ajabholi ghas hudaina. (Household interview, 06/03/2018)*

> *We used to get enough rain in past years. As a result, our rangelands could grow plenty of grass for our livestock. But nowadays, rainfall has decreased, which has also caused a decline in the grass on our rangelands. (Translation, 06/25/2019)*

Untimely rainfall was also reported by local people. A male respondent (40 – 50 years old) mentioned the shift in the timing of rainfall and further emphasized the decreasing trend of rainfall in the village, a region in which rainfall was already scarce.

> *Paani parne chai dherai nai kam vaeko chha. Paani parne chai khas yo Asar ko antim dekhi saun sama parthyo. Tara 2-3 sal bhayo aile saun antim ma ra bhadau ma parchha. Tyo paani dherai nai kam parchha. Upper Mustang ta paila dekhinai paani kam parne thau ho tara paila vanda ni aile dherai nai kam parchha. (Household interview, 06/05/2018)*

> *Rainfall has decreased dramatically. Even the pattern and timing of rainfall has changed in recent years. Usually, we get rainfall from June to July. But it has been almost 2-3 years as the pattern has shifted towards July to August. Additionally, it rains very less and for a short period of time. (Translation, 06/25/2019)*

A female respondent in her 50s raised the concern of erratic rainfall in the region. She further explained the impact of erratic, and intensified rainfall as landslides, flash floods whereas too little rainfall had a negative impact on the growth of grass in rangelands.

> *Paani thorai parepani samasya chha dherai pareni samasya chha. Thorai paryo vane ghas ramro audaina, dherai paani paryo vane pani ko kulo bagarea lagidincha. Tesaile yo gau ma ei samasya chha. (Household interview, 06/06/2018)*
>
> *Both less rainfall and high rainfall are trouble for us. If it rains low, it affects vegetation whereas when it rains too much, it brings landslides and floods which washes our lands and irrigation canal. (Translation, 06/25/2019)*

We also observed a decline in rainfall in the 1992-2014 period in our analysis (described in detail in Chapter 5) from Dhee station situated about 2.6 km from Yara. The annual rainfall decreased significantly at the rate of 8.5 mm/year.

4.2.1.3 Increased Wind Events

Increasing wind events was another major concern raised by locals during interviews. Local people mentioned not experiencing high winds in the past particularly in winter. But, in recent years, they have been constantly noticing the increasing effect of strong winds in the village. The following quote is by a female respondent in her 50s as she shared her experience of harsh wind in the village in recent years.

> *Utari hawa huri pani dherai lagne thiena paila. Tara ahile hiudo ma hawahuri pani dherai lagna thaleko chha. (Household interview, 06/03/2018)*
>
> *Before, I had not noticed such wind in our village during winter. But nowadays, the wind is very harsh here, which is very unusual for me. (Translation, 06/25/2019)*

One of the female respondents (50 – 60 years old) said that the wind has brought various human diseases in the village. She described her experience saying,

> *Aile hawa pani dherai parchha. Aile rog haru pani dherai aeko jasto lagchha. Yo sabai hawa paani le bimari bokera laeko jasto lagchha. Mata hawa dherai lageko dekhera kasto hunchha, baula jasto banaucha dherai hawale. (Household interview, 06/06/2018)*
>
> *The wind is very harsh nowadays. I feel like various diseases have been transmitted to our village because of the strong wind. It really scares me. This harsh wind makes me mad. (Translation, 06/25/2019)*

Moreover, Local Adaptation Plan for Action (LAPA) for Surkhang VDC also reported increasing wind events since 2015 with various consequences to local livelihoods and livestock. This involves injury and diseases to animals, destruction of houses and planted trees, soil erosion, and disturbance to local people's daily household chores (LAPA Surkhang VDC, 2015).

4.2.1.4 Dilemma about Air Temperature

Local people had a diverse opinion regarding air temperature. Some respondents would say it is the same as it was before, while some mentioned there is an increase in temperature. The following quote is by a young female respondent (20 – 30 years old) describing warm weather in Yara village and highlighting the change in wind events.

> *Yara gau ma aru gau haru vanda nyano hunegarcha paile dekhi nai. Tato ta ustai ho jasto lagcho paile ra aile malai. Testo bade jasto lagdaina. Tara hawa chai badi chalejasto lagcha ajakal. (Household interview, 06/05/2018)*
>
> *Yara village is considered as one of the warmest villages in the Upper Mustang region. I do not feel any changes in temperature. It is same as it was used to be before. However, the wind effect has increased in recent years. (Translation, 06/25/2019)*

A male respondent aged 40 – 50 years old expressed dilemma regarding the temperature, which seems to vary from year to year. This provides a source of uncertainty.

> *Tyo ta jado ra tato ma ta vanna sakidaina. Kunai sal ma besari chiso pani hunchha kaile thikai hunchha. Paile dekhi nai estai vaeko jasto lagchha. (Household interview, 06/10/2018)*
>
> *I cannot say anything about cold and hot weather. In some year, it is cold and otherwise it is warm other year. We cannot say. It is like this for years. (Translation, 06/25/2018)*

Some of the respondents specifically said that they have felt an increase in temperature during summer. The following are quotes by two female respondents in their 30s and 20s respectively, who explicitly said the temperature has increased in the village.

> *Aile barkhama paila vanda gham badi charko vae jasto lagchha. Garmi badeko jasto lagchha. (Household interview, 06/18/2018)*
>
> *Nowadays I feel like the sun is more intense in summer. Temperature has increased. (Translation, 06/25/2018)*
>
> *Paila ko barsa vanda aile ali garmi badeko jasto lagchha. (Household interview, 06/09/2018)*
>
> *It's getting warmer compared to previous years. (Translation, 06/25/2019)*

Mixed temperature responses were expressed by local people. Moreover, some locals could not decide whether any changes happened.

4.2.2 Rangeland Degradation

Rangeland is an important component of the ecosystem in high altitude Himalaya. It offers the foundation for animal husbandry while providing the space and resources for feeding the livestock. Therefore, local people could readily notice any kind of changes in rangelands, such as a decline in amount and quality of grass, variation in greenery, etc.

During household interviews, all households in the village mentioned the declining trend of grass in rangelands. One female respondent in her 50s talked about the availability of grass in rangelands last year compared to this year. She added how hard it has been this year trying to feed livestock as there is not enough grass in the rangelands. She also mentioned not having good snowfall this year and that being the reason for the declined grass in the rangeland.

> *Pahila ghas paani dherai ramro hunthyo. Pohor sal ghas ramro ako thyo. Tara aile hiu ramro parena tesaile ghas nai ramro aako chaina. Tesaile dherai nai garo chha aile bheda chyangra palna ahile ta. (Household interview, 06/03/2018)*

> *There used to be a good amount of grass before. Last year the grass was really good. But this year since we did not get a good amount of snowfall, there's a scarcity of grass. It has become really hard for our sheep, goats to take out for grazing now. (Translation, 06/25/2019)*

Another male respondent (40 – 50 years old) expressed uncertainty about the availability of grass for livestock and stated that the driving factor was declining snowfall.

> *Chyangra haru mathi lek ma charauna lagchha. Ghas kaile pugchha kaile pugdaina. Yo pali hiu ramro aena tesaile ghas ramro vaeko chhaina. (Household interview, 06/08/2018)*
>
> *We take our goats to high altitude rangelands for grazing. The grass is sometimes enough but sometimes it is not enough to feed them. This year due to lack of snowfall, the grass is less this in the rangeland. (Translation, 06/25/2019)*

As presented earlier, and as consistently emphasized by study participants, the growth of grasslands is primarily dependent on seasonal snowfall and water from the snowmelt in high altitude rangelands (Household interviews). Therefore, timely snowfall in adequate amounts is required for grassland growth. One female respondent (30 – 40 years old) raised this issue while linking grassland growth with lack of water in rangelands. She also recalled the greenery in rangelands from last year which she did not see this year.

> *Paila ta dherai pani parthyo, hiu ni parthyo. Yo sal ta hiu ni parena. Asti ek choti matra paryo tyo ni thorai paryo. Pani navaera lek ma ghas pani ramro chhaina. Paila ta aile hariyo huna parne ho tara chaina hiud ko jasto sukha cha pani naparera ra hiu naparera. (Household interview, 06/11/2018)*
>
> *It used to rain in good amount before and the snowfall too. This year did not receive snow at all. I think we only received once which is negligible. Our rangelands are drying due to lack of enough water. It used to be greenery all over the rangelands this time in past years but this year it is so dry just like the winter season. It is all due to lack of rainfall and snowfall. (Translation, 06/25/2019)*

The amount and quality of vegetation in rangelands are considered to be primarily determined by precipitation, which is mostly in the form of snowfall in high altitude lands (Chetri & Gurung, 2004; Paudel & Andersen, 2010). Additionally, snowfall is directly related to the soil

nutrient in the high rangelands. Declining snowfall and the shift or delay in snowfall timing was one of the major concerns described by locals in Yara.

In addition to grass in rangelands, as locals mentioned, livestock is often fed on bushy plants found in fields nearby the village. According to an elderly respondent (60 – 70 years old) in the village, even the bushes have dried and are not found in large numbers nowadays. This was also attributed to the drying of water resources in the village.

> *Paila chyangra palna sajilo hunthyo. Ghas jati pani hunthyo. Aile ta ghas chaina. AIle ta kanda pani ramro hudaina. Tyo kanda ko ful pani khancha chyangra le. taraa aile ramro hudaina. (Household interview, 06/17/2018)*
>
> *It was easier to keep goats before. There was plenty of grass. But now there is scarcity of grass. Even the bushes are not good these days. Goats eat flowers and buds of those plants. But these days they are not even not growing like before. (Translation, 06/25/2019)*

Locals often bring grass from nearby villages such as Tsarang, Marang. Additionally, due to the lack of grass, locals cannot just depend on rangelands to feed their livestock. As a result, they meet the livestock diet requirements by providing market food in addition. This includes crops such as corns, wheat, and chickpeas.

4.2.3 Irrigation Water Seepage; Problem and Mitigation Practices

The water scarcity, as described by locals and based on our observation, was noticeable with the little surface flow in *Puyung Khola*. Due to that, it is not possible to directly irrigate the farmland. Another serious problem was the water loss due to the subsurface flow of in the river. Therefore, to ensure proper management of water and supply for irrigation, water is first collected in a reservoir near the village while bringing the water further downstream (Figure 4.5 and 4.6).

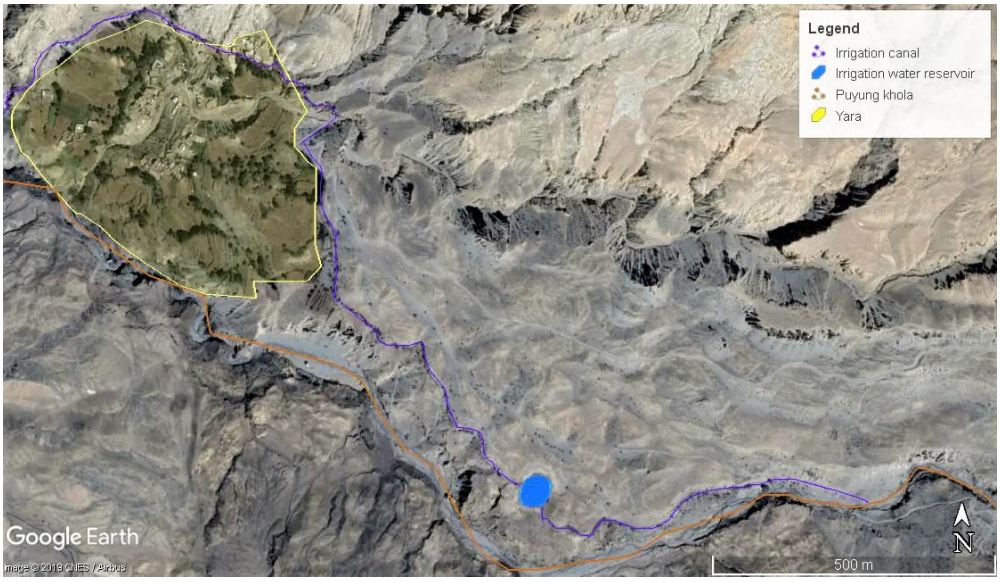


Figure 4.5. Google earth image indicating Yara and farmlands (in yellow), Puyung Khola (in brown), irrigation canal (in purple), and irrigation water reservoir (in dark blue polygon) (Source: Google Earth Pro, Date accessed: 07/22/2019)

Figure 4.6. Water reservoir in Yara (Date: June 2018, Source: Author)

The following quote is by an elderly female respondent who explains the irrigation practice carried out by locals. According to her, usually water is collected overnight and in the morning the

reservoir is opened to irrigate farmlands. Each household has its turn and is responsible for monitoring the process of collecting water in the reservoir.

> *Hamro sichaiko pani ko srot yo khola ho. esko muhan mathi lekh ma chha. Sichai ko lagi hami pani paila mathi tal ma jamma garcha. Pani belka 7 baje dekhi jamma garcha ani bihana 6 baje chodcha khet ma. Jasko khet ma pani halne palo cha ulse pani thunne ra chodne garnuparcha. Sabaiko ghar le pao laucha esari nai. (Household interview, 06/03/2018)*
>
> *The main source of water is this river. It originates from high lands in the mountains. For irrigation, we collect the water from the to the reservoir at first. We start collecting water from the evening at 7 pm until morning. And the doors are open at 6 am in the morning for irrigation. Anyone who has turn to irrigate will collect the water by following this process. We have allocated turn for each household in this way. (Translation, 07/22/2019)*

As described by locals, loss of water due to underground flow was a major problem while regulating the water for irrigation. According to local people, water passes under the ground through pores while the water leads through the river to the reservoir. To prevent the loss of water, locals have implemented a mitigation technique that consisted of putting soil on the surface of the river. According to local people, they have been practicing this technique for more than 30 years. They believe that the seepage of water is checked in some amount when the soil is placed on the surface.

In the following quote, a female respondent aged 50-60 years old describes the water seepage phenomenon further in detail. She also blamed the bad quality of soil for water seepage.

> *Tesai gari pani jamin muni chuhera pani janchha. Khai mato naramro vaera hoki pani chuhine gareko. Pahila Surkhang gauma pani sano authyo. Yehi hamro gauma aune pani chuhera uta jane garchha. Tara pachhi pachhi Surkhang gaule hamilai mato nahalna pani bhane gareko chha. Maile testai suneko. Pahila sano pani janthyo Surkhang gau tira aile dherai chuhera Janchha tasaile hamilai pani ko kami vairakheko chha. (Household interview, 06/03/2018)*
>
> *…Water gets leaked in the river bed. Maybe it is because the soil is really bad here. In past water was scarce in Surkhang village. The water which goes through seepage from our river gets to Surkhang village. I heard some people from Surkhang told our villagers not to put soil in the river. In the past there was little*

water that flowed to Surkhang but now due to high seepage, more water is lost from our river and it has resulted in a water shortage for us. (Translation, 07/04/2019)

The following quote is by a male respondent aged 50-60 years old as he recalls the practice of applying soil on the river bed (Figure 4.7) and further explains how this mitigation practice works.

Hamile testai 30 barsa aghi dekhi sichai ko kulo ma mato halne chalan gareko ho. pani sabai jamin muni chuhera jane vaeko le mato halera tya bhaeko pwal haru talne gareko ra pani bhitra jana nadine gardacha. Ma sano hudai dekhi nai malai yad cha esto mato halne chalan gardai aeko ho. (Household interview, 06/17/2018)

We have been doing this practice of applying soil in river for 30 years. We put soil on river bed to check the holes on surface and it helps to check the water seepage. We have been doing this for long as I could remember as a child. (Translation, 07/04/2019)

Figure 4.7. Locals putting soil in Puyung river to check the water seepage (Date: June 2018, Source: Author)

The following two quotes are by a male respondent aged 30- 40, and a female aged 60-70 years old as they both further elaborated the process of applying soil in the river; how each household is assigned, and how long it takes to conduct the process.

Yo sal pani ta thikai bho. Mato halera fijauchha kere pani. Hami sabai palo palo garchha mato halna. 14 ghar bata palo lagauchha. aja 7 jana gayo ani bholi baki 7 jana tesai gari palo laucha. 12 -13 din samma lagatar halne garcha barsai pichhe. (Household interview, 06/12/2018)

This year the water was ok. We put soil on the river. Every household who has farmland has to take part in this process. 14 households are assigned for this task. Today 7 household took part and tomorrow remaining 7 household will take part. This process continues for about 12-13 days every year during the cropping season. (Translation, 07/05/2019)

Hami sichai ko lagi mato halne garchhau. Ma mato halna 2 din gayo. Hami 60 -60 doko mato bokera halna parchha. Koile khanne, koile bokne, koile khane kura pakaune garchha. (Household interview, 06/17/2018)

We put soil in water to collect it for irrigating our farmlands. This year I went for two days. We have to carry 60 doko (basket) by each household. Some people dig the soil, some carry it, and some make food for all of us. (Translation, 07/05/2019)

This water seepage phenomenon was further described by one of our key informants at ACAP in Jomsom office. He further added his opinion regarding the water seepage due to open soil system of the river while linking it to fragile soil structure which is further exacerbated by drying of available water sources.

Ya ko river haru ko stream line chai kasto cha vane tapaiko open soil cha ani penetration vaera yara bata bata soil ma penetrate vaera ekaichoti Surkhang gau, Dhee gau aipugcha.. Hami pani herna sakchau Mathi Lurai gumba jada bato ma, khola khola janchau tara paani chai jamin muni muni bagirakheko huncha. Tyo baeko le bishesh gari dry season ma yo samasya chai tya ko machhe harule bhognu parcha ra yo chai tya ko geographical condition le garda nai ho ra yaha paryapta pani ko matra nahunu ra bhaeko paani pani tya ko soil composition le garda pani jamin muni penetrate vaera jane ra downstream tira seepage vaera jane dekhieko cha. (Key informant interview, 05/30/2018)

The river in this region flows in an open soil system. As a result, water gets penetrated inside the soil. Water gets disappeared from here and only emerges downstream in Surkhang and Dhee villages. We can see that water flowing underneath the ground if you follow the river on the way to Luri gumba. This is a very big problem for local people, especially during the dry season. It is also because of the geographical condition of the region with fragile soil and lack of water sources as well. Even the available water has lost and disappeared to the downstream region due to the seepage problem. (Translation, 07/07/2019)

4.2.4 Road Development and its Impact on the Community

Just ten years ago, the only way into Upper Mustang was on foot or horseback through traditional walking trails. Horses, mules, donkeys, yaks, and Dzopa (yak and cow hybrid) were the only means of transporting goods, people, and services. These animals had always been a part of Upper Mustang's landscape and culture. But now, the construction of a new road connecting Upper Mustang to southern cities (i.e. Beni, Baglung, Pokhara, Kathmandu, and other cities) (Figure 4.8) and Tibet in the northern side has offered an opening to the once-forbidden kingdom of Upper Mustang.

The road link has been viewed as a bilateral trade opportunity for China to Tibet (Murton, 2017). It is also considered as a potential way for future trade between India and China. Nepal's government has taken steps to open the Kora la borders, as China has agreed to open the six crossings (one of them is Kora la border in Upper Mustang) officially in 2012 (Tripathi, 2016). Now, the constructions of infrastructure building like customs departments are underway while the road is undergoing further upgrades while divided into different sub-sections in places.

Figure 4.8. A jeep making its way towards the way to Yara (Date: June 2018, Source: Author)

Local people were positive about the road development in the village. They were profoundly delighted with the opportunities that the road has brought to the village. For example, the road has aided in transporting groceries for households, facilitating travel to southern cities, allowing for the arrival of domestic and international tourism, facilitating commerce, among others.

A male respondent (30 – 40 years old) expressed his experience of how he perceived the road accessibility in Mustang as an impossible task and how it turned out to be a reality as,

> *Aile road pani aeko chha. Paila hami pokhara jana hidai athawa ghoda liera kati din lagthyo. Aba paila ghasa ko muni kabhre bhir ma manchhe le bato khandai thyo. Hami vanthyo aba yo bato mathi mustang sama pugda ta hami marisakcha hola vanera. Tara aile tei bato barsa ma 2 -3 choti ma afai hidnuparcha. (Household interview, 06/12/2018)*

> *Now the road has arrived in the village. In the past, we had to either walk or ride on horse to go to Pokhara city and it used to take days to reach there. We used to notice road construction work going on at Kabhre bhir (a big cliff on the way) near Ghasa village. Then we used to say to ourselves that by the time this road arrives in Mustang, we are all going to be dead. But now we travel the same road on motor vehicle two or three times a year. (Translation, 07/05/2019)*

Locals mentioned that road access has helped them transport necessary household goods and food from the market easily in a span of just one or two days. A female respondent aged 30 - 40 years old explained how transporting goods and traveling to Pokhara city has become convenient nowadays with the road connection as,

> *Motorbato aekole dherai sukha vaeko chha aile. Saman launa, yatra garna sajilo vaeko chha. Aile chamal, tarkari haru, ra aru chaine sabai saman haru truck ma launa sakincha gau ma Pokhara bata ek dui din mai. (Household interview, 06/06/2018)*

> *Life has become a lot easier now as our village is accessible by road now. Transporting goods, traveling is not a tedious task. Now the trucks from Pokhara can bring rice, fresh vegetables, and caseloads of modern goods into the village in the space of a day. (Translation, 06/25/2019)*

A key informant from Austria who has been traveling to Upper Mustang since 1992 every year shared his concerns about the development of the Upper Mustang road, while highlighting its impact on trekking tourism. The loss of trekking routes due to the motor road was his major concern. According to him, even though the road has contributed to mass tourism, at the same time it is limiting the scope of trekking tourism in the region.

> *But nowadays because of the completion of a motorable road in Upper Mustang, there will be winners and there will be losers as well. Because the trekking routes are gone. Tea houses disappeared. Tourist would travel to Upper Mustang in just one day on the motorable road and they do not stay overnight. They return back. But, the tourist who comes here for trekking does not want to walk on the motor road. They want a separate walking route where there is no vehicle and pollution. Therefore, if people build a trekking rout apart from the motor road then tourist would come here for trekking. Otherwise, there would be another kind of tourism which I call mass tourism where people only come to visit for a short time and return mostly on a vehicle. (Key Informant Interview, 06/14/2018)*

There is no doubt that physical accessibility has been increasingly improved as highways and roads have arrived in the region. However, it has some negative impact as well; particularly for trekking tourism as stated by the key informant. Trekking trails are demolished as the road construction has taken place. The state and locals should, therefore, be concerned to preserve the trekking routes or to build alternative routes apart from the development of roads.

4.2.5 Socio-Cultural Changes and Efforts to Preserve the Local Culture

The livelihoods of locals are closely bonded with social norms and values. Religion, tradition, and culture play an important role while shaping the daily life of the people (Tulachan, 2003). For instance, people have been celebrating festivals such as Yartung, Tharchyang together in the community for centuries. They gather around and bring food and drinks from each household. However, since the opening of Upper Mustang in 1992 to foreigners and with the recent development of the road in the region there have been changes in the course of festival celebration.

A female respondent (30 – 40 years old) in the community expressed her perception of local people regarding the way of festival celebration in recent years. She mentioned how the festivals have become costly and people are becoming lavish as,

> *Paila dekhi ta aile chad parwa ma dherai kharchha lagchha. mitho mitho khane vanchha ramro laune vancha ajkal ta. Paila ta k luga ni dherai ramro chaidina thyo khana ni satu haru matra bhaye pugthyo tara ajakal ta k k khane vanchha. Paila dekhi aile ta dherai pariwartan vachha. Aile sabaile ramro garne, ramro laune, ramro garchhu vanchha tara paila matra khana puge hunthyo manchhe harulai. (Household interview, 06/11/2018)*

> *Nowadays festival celebrations have become costly than before. People are attracted to eat delicious food, wearing good clothes nowadays. Before people never desired for good clothes, they only ate flour. But now people eat a variety of foods. I have seen a lot of change than before. Everyone wishes to have better food and good clothes to wear. Nowadays people have become luxurious. Before they only wished to fulfill basic needs. (Translation, 06/25/2019)*

However, people are still very much aware of preserving their culture and tradition. One local male respondent aged 30 – 40 years old explained his devotion and respect to cultural norms and traditions as,

> *Aba hamile paila paila ko chad haru aile sama chhodeko chhaina. sabai hami ramro sanga manne garchhau. Paila paila jastai gari chad haru manauchhau. Hamiile vanchha jastai 49 barsa ma tharchyang vane garachhau, tesai gari aba hamro bhadau maina ma khet katne bela yartung vane chad hunchha. Ghoda chadera pratek ghar ko 1 jana mathi luri gumba jane tya 1 rat basne garcha puja haru gari manaucha. (Household interview, 06/12/2018)*

> *Well! We still strongly follow and celebrate our festivals and traditions. We celebrate with the same joy and togetherness as it before. There a ritual called [Tharchyang] a celebration when people turn 49 years old. There another big festival of ours called [Yartung] which we celebrate while harvesting our crops. We celebrate while riding horses during Yartung festival. Each member from every household goes to [Luri Gumba] on that day to celebrate and pay homage to the holy God. (Translation, 06/25/2019)*

Upper Mustang was an isolated area until 1992. As such, the external impact in the region was very limited (Gurung & DeCoursey, 2000; Tulachan, 2003; Basnet, 2007). Following the region's opening in 1992, westerners began to enter the region, numerous organizations such as

ACAP were formed, and local people also began to send their kids to Nepal's southern towns for educational purposes. Even though education has become more important these days in the region, there is also an additional influence that results from sending their children to big cities for their schooling. Forgetting local culture, language and moving more towards town lifestyle and Nepali language choice instead of local Tibetan language was one of the main concerns posed by locals. The following quote is by the previous respondent. He raised the issue of the importance of education to children while adding,

> *Tara aile chai k bhayo vane bacha haru padna thalyo . Aba school padauna Pokhara, Kathmandu pathayo tesaile Bacha haru chai Hamro bhasa vanda badi Nepali bhasa ko geet sunne, tesai ma kura garne garchha. Hamro afnai bhasako geet hunchha, bolchha tara tyo chai ali kam vae jasto lagchha….. Aba jhan mobile ako chha. k k vanchha. Ani hamro geet haru haraune bho. Aba aile hamro bacha haru pani aja bholi ta hamro bhasa bolcha tara afu afu sathi bich ta Nepali nai bolcha aile. (Household interview, same as above)*
>
> *But now what has happened is…. Our children go to school and want to do high education. For that they are sent to Pokhara, Kathmandu. As a reason they got away from our culture and are living in city environment where they communicate in Nepali mostly, listen to Nepali songs. We have our own Tibetan language, Tibetan songs… but nowadays I feel like our children are less attracted to our own language and traditions. Additionally, there is mobile phone nowadays!! Our songs will disappear. Our children speak the Tibetan language with us but when it is between their friends they speak in Nepali. (Translation, same as above)*

Locals are dedicated to preserving their culture and tradition. But with enhanced accessibility and growth of infrastructures, people are modernizing with improved education, modern technologies, and communications systems; altering their lives. The relationship that the region has had with the external world is changing rapidly with roads and new technologies. Moreover, globalization is a growing threat in the region.

4.2.6 Market System and Changes

In the Upper Mustang region, both internal and external markets have played an important role in shaping the livelihoods of local people for centuries. In the past, market system was in the form of barter exchange (Tulachan, 2003). Upper Mustang residents and Tibetan traders were free to travel and trade across the border. Locals exchanged locally produced grains such as wheat, buckwheat, for salt, and livestock with Tibetan traders (Jackson, 1984; Tulachan, 2003). After acquiring goods from Tibetan traders, locals traveled south for next bartering with traders from southern Nepal. Southern Nepal had enough rice and grains, but a deficit in salt. As such local people exchanged salt with grains such as rice, and lentils. In the following quote, a male resident (aged 40 - 50 years old) in Yara told about the ancient trade practiced by his grandfather as,

> *Pahila pahila baje ko palo ma chyangra ma bhari bokaera hamro mustang bata tala nun liera janthyo ra pachhi tala bata chamal, dal haru bokera mathi lauthyo. Mero palo ma ta nun laena tara. Paila paila tesari byapar garthyo. (Household Interview, 06/08/2018)*
>
> *In the past, my grandfather used to transport loads of salt on the back of goats from Upper Mustang to the southern region and in exchange, they would bring rice, lentils. This practice lasted until my grandfather's generation and was a major practice by locals. However, we did not practice such activity coming to our generation. (Translation, 07/25/2019).*

However, this practice came into an end in 1959 after China invaded Tibet (Jackson, 1984; Tulachan, 2003) and the ancient trade transformed into a new structure with strict supervision by China.

Currently, a Chinese administered semi-annual trans-border trade fair is held twice in a year in the Tibet region (about 13 km inside Tibet from the border) for local traders from Nepal and Tibet. A northern road connecting Tibet to Upper Mustang serves for the transportation which was built in 2004 by locals themselves. During the trade fair, local merchants from Upper Mustang participate while selling local handicrafts, goat/sheep wool, and medicinal plants to Tibetan

merchant. Similarly, shop keepers import household utensils, electronic appliances, clothes, manufacture foods later to be sold in local markets.

Figure 4.9. Locals from Upper Mustang loading Chinese commodities in a tractor purchased on trans-border fair in Tibet (Date: June 2018, Source: Author)

Now, the goods and food requirement of locals are also partly fulfilled by markets in the Southern cities of Nepal. With the recent development of road, connecting the region to Jomsom, the headquarters of District as well as Jomsom with the southern cities such as Beni and Pokhara, local people now prefer to bring grocery items from southern cities in Nepal for which people were completely dependent on Tibet in past years. However, manufactured goods such as blankets, carpets, clothes, furniture, and beverages (Figure 4.9) are still imported from Tibet as the cost of Chinese products is lower than bringing it all the way from cities in the south of Nepal. The following quote is from a male respondent in his 30s as he shared how their dependence on necessary goods has changed with the accessibility of road in the village.

> *Paila motor bato naune bella sama mathi china bata 25 kg bora chamal ko 750 kinera khantyo. Aile ta sabai Beni, Pokhara bata laucha. Mathi ko mitho pani lagdena aile ta. Sabai tala bata laucha. Chamal mathi bata laudaina aile. Tara aru*

saman haru jastai beer, blanket, chulo, furniture haru sabai china bata nai aucha. (Household interview, 06/12/2018)

We used to buy 25 kgs of rice in rs. 750 from Tibet region of China in past when there was no road connection to our village from southern cities. Now we bring grocery items from cities like Beni, Pokhara. Chinese rice does not taste good as well. So we do not buy them now. But other goods such as beer, blanket, carpet, cooking ovens, furniture, etc. We still buy from China. (Translation, 06/25/2019)

The market system has shifted from ancient bartering trade to buying of Chinese manufactured modern commodities, and now leaning towards southern cities with road facility. However, the Chinese goods and food imported from Tibet still dominate and fulfill most of the local demands as they are cheap compared to southern markets in Nepal.

4.2.7 Pest Outbreaks and Diseases in Crops

Damage of crops by pest and diseases (Figure 4.10) was another issue mentioned by locals among the changes of concern. These represent additional problems that locals encounter each year in the farmland, in addition to the lack of water for irrigation. According to locals, pests are usually seen in June-July in large numbers when the wheat is grown in the farmlands.

Figure 4.10. Pest as seen in a wheat farm in Yara (Date: June 2018, Source: Author)

The first and second quotes are by male respondents in their 30s and 50s on pest problems and the methods of control respectively, while the last quote is by a female respondent in her 50s as she expressed increasing trend of pests in crops.

> *Tesai gari aile bali ma kira haru nai dherai aucha. Tesko roktham ko lagi hami lama puja garchhau. Hami testo kira marne ausadhi haru haldena. Hamro dharma ma marna rarmo mandena. (Household interview, 06/16/2018)*
>
> *Similarly, nowadays we see large numbers of pests in our crops. To control such pest in crop we do monk ritual of worshiping. We do not use pesticides. Killing is against our religion. (Translation, 06/25/2019)*
>
> *khet ma kira haru pohor khasai lagena parar lagyo ra aile pheri dherai dekhieko chha. Hami kira haru roktham ko lagi lama pooja lagauchau. Ausadhi prayog gardena hami. (Household interview, 06/17/2018)*
>
> *Last year we had less pest in crops, but there were in large numbers two years ago. Similarly they are in large numbers this year too. We do not kill pest with pesticides instead we do monk worship to control them. (Translation, 06/25/2019)*
>
> *Paila paila kira dherai kam authyo balima.Tesaigari aile khet bari ko bali ma kira haru panni auna thaleko chha barsai pichhe. (Household interview, 06/03/2018)*
>
> *I used to see very less pest in crops in past years. But now the number is increasing every year. (Translation, 06/25/2019)*

Increase of pest outbreaks in crops has also been recorded by ACAP in Yara and surrounding villages. According to the report of LAPA, such incident has become more prominent since 2009 while causing severe damage to crop such as wheat, buckwheat, and barley.

4.3 Transforming Structures and Processes; Available Institution and Administration System

The Upper Mustang region is designated inside the Annapurna Conservation Area (ACA) and is managed by Annapurna Conservation Area Project (ACAP). Since its establishment in 1992, ACAP has been working to conserve natural resources while regulating sustainability to support local livelihoods (Figure 4.11). During one of the key informant interviews, a conservation officer from the ACAP office in Jomsom further elaborated on the roles of ACAP saying,

Ma Annapurna Conservation Area Project (ACAP), Unit Conservation Office Jomsom ra Lomanthang ma karyalaya pramukh ko rup ma 2 barsa dekhi conservation officer ko pad ma basera kam gardai chu. Sanstha ko karya ko kura garnuparda yo 1992 dekhi chai Mustang jilla ma ACAP sthapana bhaera samrakshan ra bikash ko lagi hami 3 wata objective liera kam gardai aaeka chau. Mukhya 1st ta yaha ko prakritik srot ra sampada haruko samrakshan garne, 2nd ya ko community haru ko livelihood ma sahayog puraune ra 3rd yaha ko parayparyatan lai pani prawardhan garne vanne hamro mukhya objective cha. Tyo sanga sambandhid NTNC ko tatkalin 11 ota thematic area chha. ra hamile 9 ota thematic area ma chai Mustang jilla ma kam gardai aeko chau. Jasma Natural resource conservation euta chapter chha, tesaigari tourism promotion, tourism management, ani conservation extension education, tesai gari samudaya ko bikash ko lagi CIDP, Community development programme vane pani hamile gardai aeko chau. Tyo sanga related karyakram haru hamile yo mustang jilla ma krisi ko karyakram haru pani Upper mustang ma garchau, tesai gari krisi ra swasthya ko duita karyakram haru pani garchau, tyo vanda aru yo sanstha le garne vaneko research ra documentation ko kam pani garchau. Esari 9 ota different thematic area ma hamile sthapana kal dekhi nai kam gardai aeko chhau. (Key informant interview, 05/30/2018)

I have been working as a conservation officer at ACAP, Unit conservation office in Jomsom and Lomanthang. It has been 2 years now. Talking about ACAP, it was established in 1992 in Mustang and since then it ha been working for conservation by following 3 distinct objectives. The first objective is to conserve natural resources. Second is to help local people's livelihood. And the third is to promote and regulate nature-based tourism. We have 11 thematic areas based on these three objectives under the organization National Trust for Nature Conservation (NTNC) under which ACAP operates. We have been working on 9 thematic areas in the Mustang region. It includes natural resources conservation, tourism promotion, and tourism management. Additionally, we also work on conservation extension education, community development through community development programs. Furthermore, we also work in the agricultural sector where we provide technical and financial assistance. Other than that, we also do research documentation in the region. In this way, we have been working in 9 different thematic areas in Mustang district since our establishment. (Translation, 07/05/2019)

Figure 4.11. Locals during LAPA preparation workshop in Dhee village (Date: June 2015, Source: Author)

When local people were asked about available institutional support, they mentioned receiving assistance from ACAP to support their livelihoods. This included technical and financial assistance in the maintenance of irrigation water canals, building walls around farmland, repairing monasteries, and religious stone walls, and implementing tree plantation programs. The following quotes are by a male aged 40-50, and females aged 20-30 and 50-60, respectively as they mentioned about the contribution of ACAP in the community.

> *ACAP le tyo pariko gumba banauna sahayog garyo. Ani biruwa haru pani ropna sahayog garyo. (Household interview, 06/08/2018)*
>
> *ACAP helped us to repair the monastery. Similarly, they also helped in tree plantation. (Translation, 07/05/2019)*
>
> *Kulo haru banauna, khet ko parkhal lagauna ACAP le sahayog gareko chha. (Household interview, 06/09/2018)*
>
> *ACAP has helped us to repair our irrigation cannals and to build walls around our farmlands. (Translation, 07/05/2019)*

> *Tesai gari ACAP le pani mathi Lurig gumba marmat garna, parkhal lagauna, brichyaropan sahayog gareko cha. (Household interview, 06/04/2018)*
>
> *..In addition, ACAP helped us to repair Luri gumba (monastery), build walls in farmland and tree plantation. (Translation, 07/05/2019)*

While ACAP is the major organization in the Upper Mustang region, government offices are also actively involved in supporting local livelihoods. Every year, a certain amount of budget gets allocated for the region to support local people's livelihoods through various development programs such as water resources management, agricultural production improvement, road maintenance, tourism management, etc. One of the male respondents aged 30-40 years old shared his knowledge about the recent changes that happened in the government system of Nepal as the country went through the reformation of administrative divisions into more decentralized province system. He also expressed his lack of understanding regarding the administrative changes.

> *Aba paila ko vanda aile dherai change vaechha. Paila ta budget ayepani kendra bata authyo tara aile ta khai gaupalika vane aechha. Paila paila ta pancha bewasta vane hunthyo. Tesari chalauthyo. Tespachhi k ayo loktantra aayo. Ra aile gaupalika vanne aayo…. Tara maile aile sama bujna sakeko chhaina yo gaupalika ko barema. Kunai yo gaupalika dherai ramro ho vanchha kasaile chhaina vanchha. (Household interview, 06/12/2018)*
>
> *Well, there have been changes. In the past, the budget used to get allocated from central government but now it comes through rural municipality system. Before, there was Panchayat (a council system). Then the democracy came in the country. And now its rural municipality system that has newly formed… But I have not yet understood what rural municipality is!! Some people say it is good for us.. Some say it is not!! (Translation, 07/05/2019)*

Given the lack of higher education and the skills required, local participation in government and other non-government organization offices is negligible. The majority of jobs offered at the governmental and non-governmental offices in the Upper Mustang region are fulfilled by individuals from the southern part of Nepal. Regarding this matter, the earlier respondent further went on to share his thoughts about the participation of personnel from other regions and how it made it difficult to deal with and share his problems in administration level. Moreover, he said it

would have been convenient if their own local educated population could take a position in various administration sectors.

> *Aba k ho vane mathilo post ma hune manchhe chai pade lekhe vaepachhi afnai gau thau ko manche vae pachi hami nabujne manche lai sajilo huntjhyo jasto lagcgha. Afnai bhasa bata kam garna sajilo hunthyo. Aba yaha tala ka kako manchhe auchha. Hamro bhasa boldena. Ani garo vae jasto lagchha. (Household interview, Same as above quote)*
>
> *Well, I wish there were our own local educated people at different post in administrative divisions. It would have been much easier for uneducated people like us. We could have communicated in our own Tibetan language to better understand us. But now people from another region come to work. They do not speak our language. And it is hard for us to make good contact and understanding. (Same as above translation date)*

ACAP has been instrumental in supporting local livelihoods in the region. The evolving governmental structure, though, appears to be causing some difficulties for the local population. In addition, some locals expect local participation in the administrative system in order to provide more effective assistance for local development.

4.4. Prevalent Livelihood Activities, Opportunities, and Constraints

Given the harsh socio-ecological conditions of the region, just a single mode of livelihood could not help the local people to survive in the region (Tulachan, 2003). As a result, the local people are engaged in multiple livelihood activities for fulfilling their daily needs. This mostly includes agriculture, animal husbandry, wage labor work, and various traditional income-generating works.

4.4.1 Agriculture – "it is must, but it is not enough"

In Yara, arable land is extremely limited with only 14 households owning farmlands. Mostly farmlands are cultivated by the owner household. However, some farmlands are also offered on lease to other households; mostly to households who do not own one. Given the harsh

climatic condition, there is only one growing season. The major crops are produced in the village are wheat (Figure 4.12), potato, and green vegetables such as spinach, cabbages, and carrots. The following quote is by a male respondent aged 30 – 40 years old which illustrates the agricultural cycle of planting and harvesting of wheat in the village. According to him, the planting season starts in February – March, and crop is harvested in August – September.

> *Ek baali matra hunchha Yara gau ma. Mukhya baali bhaneko gau ho hamile lagaune. Falgun ma haami baali lagauchhau ani bhadau lagepachi hami bali katchhau. Aba bhadau maina lagepachhi yo khet haru sabai katchha ani thyakka 6 maina yo khet haru sabai khali ho. Dheri manchhe haru aba baali bhtraye pachhi pokhrara tira janchha koi chai ei ghar kurera basne, bheda chyangra herne ho. (Household Interview, 06/12/2018)*
>
> *There is only one growing season in our village. Wheat is the major crop that we grow in our farmland. The sowing starts in the month of February-March. After 6 months wheat is harvested. The harvesting season usually takes place in August-September. After harvesting, farmlands are completely left fallow for 6 months until the next plantation season. As the agriculture season ends most of the people temporarily migrate to southern cities (Pokhara) while some stay in the village and look after their home and livestock. (Translation, 06/23/2019)*

Figure 4.12. Locals weeding in farmland cultivated with wheat in Yara (Date: June 2018, Source: Author)

During household interviews, one elderly male respondent (50 – 60 years old) from the village said that the production does not completely support the food needs of a household. He further mentioned the wheat produced form farmland is limited and only lasts for a few months.

> *Hamro gau ma Kheti bhaneko ek bali matra hunchha. Hamile Gau matra ropne gareko chha. Tesbata aeko baali jamma 10-12 muri matra auchha. Tesle barsa bhari pukdaina. Hami kheti pati garyo vanne matra ho khana lai pugdaina. Yo khetipati vanne dukkha matra ho hamilai faida kei chhaina garera. (Household Interview, 06/17/2018)*
>
> *We only grow one crop in a season. We only plant wheat here. The harvest amount is approximately around 10-12 muri (a unit of mass, 1 muri = 67 kgs). However, it is not sufficient for year-round consumption. Agriculture is just a livelihood activity we do in name. It does not fulfill our food needs. It is a complete hard work which pays back nothing to us. (Translation, 06/23/2019)*

A male respondent (40 – 50 years old) who has leased farmland shared his experience in the following quote. He has been growing crops on leased farmland for nine years. He further explained farming as a tedious task with not enough return for the household. As a result, they have to buy most of the food from the market.

> *Mero afno khet chaina. Maile sau ko khet kamaera khane garchu.khet ropna thaleko 9 barsa bhayo. 3-4 barsa aghi ramro bali aako thyo. Tespachi bali bigryo. Tara khet ropera testo dherai faida chaina. Sabai kura kinera launa parchha. Gai bastu ko lagi makai ghas dekhi hamile khane kura haru sabai kinera laune garchhau. (Household interview, 06/05/2018)*
>
> *I do not have my own farmland. I have burrowed some piece of land from a local neighbor household. It has been nine years now. I used to get good crops three to four years ago. But, after that production has been decreased. And agriculture does not yield any profit. We have to buy most of the food from market. Foods for our livestock such as corn, wheat, grass are also brought from market. (Translation, 06/23/2019)*

Figure 4.13. Irrigation canal in Yara (Date: June 2018, Source: Author)

As mentioned earlier, the farming system of Yara village is totally dependent on water from irrigation. The major source or say the only source of water is from *Puyung river* that supplies irrigation water for farmland (Figure 4.13). This river is fed with water accumulated from snowmelt and hence the river levels highly depend on the snowfall during the winter season.

During household interviews, when local people were asked about agriculture, the first thing they would say was lack of water for irrigation. One female respondent aged 50 – 60 years old said agricultural production has decreased as compared to past years. Additionally, the lack of water has also forced people to abandon their farmland.

> *Kheti pati paila jasto aile hudaina. Paila kheti pati ramro hunthyo. Tara aile paani kam vaera kheti ramro hudaina. Paari ko khet haru sabai lagauthyo paila tara aile paani napugera sabai bajo chodeko cha. (Household interview, 06/03/2018)*
>
> *Agriculture production is not the same as before. We used to produce in good amount, but now agricultural production has drastically reduced due to lack of irrigation water. We are forced to abandon our farmland. (Translation, 06/23/2019)*

I could clearly see the remnant of abandoned farmland (Figure 4.14) on the other side of the village across *Puyung River*.

Figure 4.14. Abandoned farmlands in Yara (Date: June 2018, Source: Author)

A male respondent (40 – 50 years old) further explained the abandonment of farmland while pointing at the fallow lands with his hand. It's been 10 years since local individuals stopped farming these lands, as he could remember.

> *Aba jagga ta chha. Paila uta pari dekhnuuncha pari kati khet chha. Tya paani napugera aile sabai bajo nai chha. Paila paani pugthyo teha khola bata laera lauthyo. Tara aile paani sukdai gayo ra bistarai pariko jagga khali bajo chhodai gayo. (Household interview, 06/10/2018)*
>
> *We have enough farmland. You can see, we have large farmland across the stream. We used to cultivate those land before. But, now we have abandoned those lands due to lack of irrigation water. It's been more than 10 years now. It's all barren now. Before, we used to bring water from this river through irrigation canal. But, with the decreasing trend of water, we had no choice except abandoning those fields. (Translation, 06/23/2019)*

Even though agriculture has been a major livelihood activity for locals, the production is limited. It does not, therefore, support the food requirements of locals alone. Apart from the

restricted arable land, the irrigation water is declining rapidly. Locals also mentioned frequent damage of irrigation canals due to flash floods during summer. The following quote by a female respondent (aged 30 – 40 years old) illustrates the damage caused by flash floods to irrigation canal each year. Another elderly female respondent (aged 50 – 60 years old) linked the occurrence of flash floods to often short period high rainfall during summer, which is presented in the second quote.

> *Tara barkha ma khola ma badhi aera sabai kulo bagaera lagcha. Ani marmat garna parcha bela bela ma. (Interview, 06/ 05/2018)*
>
> *But during summer, irrigation canal gets destroyed by floods. As a result, we have to repair time to time. (Translation, 07/25/2019)*
>
> *Paani thorai parepani samasya chha dherai pareni samasya chha. Thorai paryo vane paani pugdaina, dherai paani paryo vane pani ko kulo bagarea lagidincha. Tesaile yo gau ma ei samasya chha. (Interview, 06/04/2018)*
>
> *Both little rainfall and high rainfall are troublesome for us. If it rains little, we are out of water whereas if it rains too much it washes our irrigation canal. This is the greatest concern in our village. (Translation, 07/25/2019)*

4.4.2 Animal Husbandry

Livestock rearing is an integral part of local people's livelihood. Goats, sheep, cows, and horses are the major livestock kept by the local people in Yara village. Livestock serves multiple multiple livelihood purposes. Goats and sheep constitute the requirement of meat and in some amount for the dairy product for local consumption. While cows are kept for milk. Other than consuming livestock products local people also sell livestock's meat and wool (sheep and goat) in the market; wool is usually taken to Trans-border trade fair and sold to local merchants in Tibet. Additionally, every year hundreds of goats/sheep are transported to southern cities of Nepal during the time of Dashain (one of the major festivals in Nepal among Hindus).

Apart from domestic consumption and the financial purpose, livestock is crucial for extremely important for agriculture; particularly as a source of fertilizer, for plowing farmland (dzopas), and for hauling (horses). In addition, livestock also helps to meet the energy needs of local people. Cow dung and goat/sheep pellet are used as a source of fuel for cooking and heating up the houses in winter. Horses are kept as a major means of transportation.

Goats/sheep are mostly grazed on rangelands. They are taken for grazing in the early morning and are returned back to their shelter in the evening. Horses, cows, and dzopas are usually stall-fed with grass, corns, wheat, and chickpeas.

Table 4.2 shows the available number of livestock in Yara. A total of 1,850 livestock are recorded in 2018 (Fieldwork in June 2018). Out of which, there are 29 horses, 46 cows/dzopas, and 1,775 goats/sheep. The table shows an increase in number of livestock in 2018 as compared to 2012; cows/dzopas increased by 15 whereas the sheep/goat showed a huge rise in number i.e. 474. The number of horses remained the same in the last six years.

Table 4.2. Number of livestock owned by households in Yara in 2018 compared to 2012.

Livestock Type	**Numbers in 2012 based on Bernet el., (2012)**	**Number in 2018 based on my fieldwork**
Horses	29	29
Cows/Dzopas	31	46
Goats/Sheep	1,301	1,775
Total	**1,361**	**1,850**

A total of 12 households interviewed mentioned livestock rearing as one of the major activities, which have been carried out for generations (Figure 4.15). The activity has substantially

supported rural livelihoods in by providing meat, milk, wool (Figure 4.16), and also have monetary value if sold. During one of the household interviews, a male respondent (30 – 40 years old) described livestock rearing as his major livelihood activity, serving both subsistence and commercial purposes.

> *Hami chyangra paleko chha. Testai 200 ota chha. Aile mathi goth ma chha. Herna ko lagi 1 ota gothalo rakheko chha. Thulo chyangra hamile bechchau ani tesbata amdani hucha. Tesaigari chyangra ko gobar ago balna pani prayog garcha hami. Hamro Zhopa pani cha. 4 ota chha. 1 ota Ghoda pani chha. Gai 2 ta chha. (Household interview, 06/12/2018)*
>
> *I have kept goats. There are around 200 in total (goats). They are taken to rangelandscurrently. I have kept one herder to look after them. We sell grown up goats in market and make money out of it. We also use dried goat and sheep pellets as a fuelwood. I also have 4 dzopas (Hybrid of cow and yak) and 2 cows. (Translation, 06/23/2019)*

Figure 4.15. A local herder taking the flock of sheep/goats to rangelands for grazing in Yara (Date: June 2018, Source: Author)

As described by the above respondent, sheep/goats are a great source of income generation for households; generally, based on the records from fieldwork the herd numbers range from 10 to

220 depending on how well-off the households are. Usually, a small number is kept by poor households whereas well-off households keep a large herd of sheep/goats for trading purposes. The following quote is by a male respondent (30 – 40 years old) in possession of a large herd of goats. According to him, goats are bought from a local merchant in Tibet during the transborder trade fair which takes place in September – October. He further said that those goats are sold to merchants in southern cities of Nepal once they are fully grown up.

> *Tesai gari chyangra haru ni paleko chha. testai 150 ota jati chyangra cha. Ghoda 2 ota cha. Chyangra haru aile maile mau paldena khasi haru matra palcha. Sabai china bata kinera laucha. Byapari haru asoj-kartik ma yaha bechna aucha. Sano sano patha haru kinchau ra palchau. Ani 4 barsa jati palepachi hurkincha. Tespachi bechchau tala pokhara lagera. Tei bata amdani huncha. (Household interview, 06/16/2018)*
>
> *Additionally, I have also kept goats. They are 150 in total now. I also have 2 horses. Goats have been brought from Tibet. We buy from the local merchant. Mostly we bring offspring of goats in September- October. We feed them well and they become ready to be sold in 4-5 years. We sell them in the market in southern cities (Beni, Pokhara). That is how we make money for our living, (Translation, 06/23/2019)*

Figure 4.16. Locals extracting goat hair in Yara (Date: June 2018, Source: Author)

He further told about additional income generation from horses as they are being used as means of transportation during the pilgrimage season. According to him, horses are hired by pilgrims while they travel to *Damodar Kunda* lake, a holy place situated near Yara village (Figure 4.17). They are paid around NRS. 7500 (75 USD) for a round trip from Yara village to *Damodar Kunda* lake.

> *Ghoda palna thikai cha. barkha ma pani ramro ayo vane ghoda lai lek mai lagera chodchau. Ghoda bata aile tei damodar kunda jane tirtha yatri lagera ali ali amdani huncha. Afu hidera jana sakyo vane ra tirtha yatri ramro ayo vane ghoda bata amdani cha. Hami palo garchau ghoda dorauna. Aba maile mero ghoda pathayo vane maiile tyo doraune manche lai 1000 jyala dina parcha. Euta ghoda bata testai 7500 jati jyala linchau. Testai sardar ma ek barsa ma 5-6 choti sama ghoda damodar kunda jancha tirtha yatri liera. Tyo amdani le ghoda lai dana khuwana pugha. (Household interview, 06/16/2018)*
>
> *It is alright rearing horses. In summer, we take our horses to rangelands for grazing. Horses are used as a means to carry pilgrims. They help them transport to holy Damodar Kunda (lake) and bring them back to the village. We villagers, assign 5-6 person to look after horses during the trip. Whoever is available takes part in the trip. Suppose, if someone sends his horses then he should give 1000 rupees as a wage to the person who looks after his horses. We charge 7500 rupees (USD 75) per person for the whole trip. This trip happens approximately 5-6 times every year. The money earned compensates the cost of food for horses with some profit. (Translation, 06/23/2019)*

Another male respondent aged 40 – 50 years old described the seasonal pattern of horse service provided during the pilgrimage season which lasts for two months every year beginning mid-May to mid-July.

> *Mero Ghoda 3 ota chha. Ghoda le aba yo jeth ko 15-16 dekhi mathi damodar kunda jane season hunchha. Yo sal ma 2 choti gaera aisakyo. Season ma 7- 8 patak samma jane garchua hami ghoda lagera. aba bholi dekhi aja audai chha. Ani 2 maina sama yo season chalchha. Jeth ko 15 dekhui saun ko 15 samma. Damodar kunda jana ko lagi yatri haru aune garchan. (Household interview, 06/10/2018)*
>
> *I have 3 horses. I have been using them as a medium for transportation. They are being used to carry pilgrims during the pilgrimage season beginning from Mid-May to Mid-July. The season lasts for 2 months. This year, our horses have traveled*

twice so far. Every year, horses are taken 7-8 times to Damodar Kunda. (Translation, 06/23/2019)

Figure 4.17. Pilgrims on their way to *Damodar Kunda* (Date: June 2018, Source: Author)

During interviews, locals mentioned the lack of grass in the rangelands in recent years. Every respondent raised this issue of lack of grass for their livestock (sheep/goat) during household interviews. In the first quote, an elderly male respondent (60 – 70 years old) recalled his past memories and told that the grass has dried up over the past years. According to him, lack of rainfall has resulted in a decrease in the grass in the pasture. As a result, local people have to buy grass from a nearby village Tsarang and transport it to the village in the tractor (Figure 4.18). Another male respondent aged 30 – 40 years also mentioned lack of rainfall as the cause of declined grass in the rangelands which is presented as the second quote below. He further explained that a total of 50 rucksacks of corn is required to feed a herd sized 100 – 150 goats; bought from the market.

Lek haru pani sabai sukyo. Chyangra, ghoda, gai lai khane ghas nai chhaina. Aakas bata paani aepachi lek ma ghas authyo ra gai bastu charauna lagthyo tara aile ta Tsarang, marang bata ghas tractor ma bokera kinera laera khulauna parcha. (Household interview, 06/10/2018)

Rangelands have totally dried out nowadays. There is no grass for our goats, horses, and cows. If we get a good amount of rain and snow, then grass grows well in the pasture. And in the growing season, we take our livestock for grazing. But, now the grass is scarce. We have to feed our livestock by bringing grass for Tsarang village (nearby village from Yara). We have to transport a huge amount of grass on a tractor every year. (Translation, 06/23/2019)

Paani dherai parthyo ra ghas pani ramro hunthyo. tara aile ta paani ramro naparera makai dina parchha. Sabai tala bata kinera lauana parchha. aile ta 100-150 chyangra palyo vane makai 50 bora jati kinera launa parchha. (Household interview, 06/12/2018)

We used to have enough grass for our livestock in the past. But, nowadays due to the decreasing rainfall, grass does not grow well. As a result, we have to buy foods such as corn, wheat from the market to feed our sheep and goats. If we keep 100-150 goats/sheep then, they require approximately 50 rock sack size of corn every year. (Translation, 06/23/2019)

Figure 4.18. Locals collecting grass brought from Tsarang. Tractors are used for transportation. (Date: June 2018, Source: Author)

Locals also mentioned incidents of livestock depredation by snow leopards, wolves, and sometimes even by eagles; these cases have been reported mostly in other villages in Upper Mustang, and no recent reports of livestock depredation have occurred specifically for Yara

village. Instead, locals stated the preventive measures taken to control such incidents from happening. According to a male respondent (40 - 50 years old), baby goats and lambs are kept inside corrals since they are the most vulnerable to predatory wild animals. They are fed with corns bought from the market and only taken for grazing when they are grown up.

> *Kita gai bastu paldai napaleko ramro tara palepachhi ramro sanga herchaha garnu paryo. Aile ni goth bhitra chha sabai patha haru. Patha haru lai ama sanga charauna lagyo vane hiu chituwa, syal, chil le lagdinchha tesaile goth bhitra rakhne garchau. Tini harulai khane ghas napugera makai kinera khuwairakecha. (Household interview, 06/05/2018)*
>
> *Either you do not keep livestock or if you keep it, you should take good care of them. Currently, baby goats and lambs are kept inside the corral. There are high chances that they would be killed by snow leopard, wolf or even eagles If they are taken out for grazing along with their mothers. Therefore, we keep them safe inside corrals. We feed them with corn bought from the local market. (Translation, 06/23/2019)*

Even though keeping livestock is an important livelihood activity, it has become increasingly costly in recent years due to the scarcity of grass in rangelands. As stated by local people, locals have to spend a large amount of money to feed livestock with the food brought from markets.

4.4.3 Wage Labor

Historically local people used to travel south in search of work. This mostly included labor work such as working in farmlands. According to local people, the leading factor for such kid of distant labor work was the existing single cropping season in the village. In this process, after harvesting crop in the village, local people descended down as far as to villages in Lower Mustang. During a household interview, a male respondent (aged 40 – 50 years old) recalled his past experience and said that his brother and he used to go up to Taglung village in search labor work. He said they moved to the next village as the work was completed in one village and so on.

> *Paila paila Hami dui daju bhai taklung, lete tira bali ko kam garna gayo. Hami testai ek mahina kam garera 300-400 jati kamai hunthyo. tukche, kobang, marpha hudai bistarai mathi gau ma kam gardai gardai authyo. (Household Interview, 06/08/2018)*
>
> *In past, my brother and I used to go down to Taklung, lete to work in farmland. We used to work for like one month and earn NRS. 300-400 (3 – 4 USD). Beginning from Taklujng, we used ascend upwards towards Kobang, Tukuche, and Marpha and finally come back to village. (Translation, 07/25/2019)*

However, this kind of labor work is not in practice nowadays. As the prior respondent clarified, they finally ended this trend when local people began working on their own farms in the village and began diversifying their livelihoods with other activities like running hotels and businesses.

> *……Tara pachhi pachhi chai tesari kam garna chhadyo. Pachi hamrai gau ma kheti patiko kam haru huna thalyo ani hami tala gau haru ma jana chhodyo. manche haru bistarai byapar bewasaya, hotel tira ni lagna thalayo pachi bistarai. tesaile hami jana chadeko aile. (Same as above)*
>
> *But later we stopped working like that as there was plenty of farmwork in our village itself. So, we stopped going down in the south. (Same as above)*

Such kind of distant wage labor system was in practice until 1993 (Key Informant Interview, 06/13/2018). As Upper Mustang opened to international visitors in 1992, tourism flourished in the region. As a result, other various livelihood opportunities started growing in the region.

There is a different type of labor system currently available that includes work-sharing among local households in the village (Figure 4.19). Such work is a major source of income for those with no farmland or any livestock possession to sustain household's livelihoods. There were five households in June 2018 that were labor work dependent and mostly in the poorer category. A female respondent (30 – 40 years old) from such type of household said that she earns money

and a meal from wage work. According to her, it was the only source of income generation for her household.

> *Hami ta arakako kam garera kamaera khane manchhe ho. Hamro kheti pati kei chaina. Hamile bheda chyangra pani paleko chaina. Jyala kam garera testai 250 – 300 jati aucha paisa ek din ko. Tesma kam gareko bela khana pani dincha hamilai. (Household interview, 06/11/2018)*
>
> *We make our living by doing wage labor. We do not have any piece farmland. We have not kept any livestock either. We get around 250 -300 Nepali rupees per day wage and we are also provided with a meal with that. (Translation, 06/23/2019)*

Figure 4.19. A woman working in farmland in Yara (Date: June 2018, Source: Author)

She also explained how the labor system works and said that it mostly includes working at neighbor's farmland; building houses; checking dams, walls, water canals, and other infrastructure; and repairing walking trails in and around Yara village. Further, she said that both men and women are equally paid for labor work in Yara village, unlike other villages.

> *Hamro gau ma mahila ra purush lai jyala dar eutai chha. Testo farak gareko paeko chaina maile. Tara charang, marang gau tira farak farak chha. Mahila lai kam dine gareko chha. (Household interview, 06/11/2018)*
>
> *Both male and female are paid equally in our village. I have not seen any discrimination regarding the wage here. However, in other villages such as Charang, and Marang, the wage rate is different where female is usually paid less. (Translation, 06/23/2019)*

In other cases, wage labor is used by elder people unable to work their lands due to the physical intensity to work the land in such harsh environmental conditions. One elderly respondent (50 – 60) mentioned about her inability to work in farmland and how she has to depend on other people from the village for most of the farm work as,

> *Pahila hami aafai kheti patiko kam garthyo. Tara ahile nasakne bhaera manchhe lai jyala diera kam garauna parchha. Tesai mathi manchhe pani paudaina ajakal. Jyala pani dherai magchha ahile. (Household interview, 06/03/2018)*
>
> *We used to do farm work by ourselves before. But now we have become old and cannot work. We have to ask other people for all the necessary work in farmland. Additionally, they ask a really high amount of wage nowadays. There is a shortage of labor as well. (Translation, 06/23/2019)*

Wage labor work is one of the key livelihood activities for poorer households and an important source of income in Yara. It has also supported elderly people while providing farm labor. In the last three centuries, however, the dynamic of labor work has changed from people moving to other villages in the lower region to working in their own village.

4.4.4 Local Traditional Activities that Support Income Generation

Apron weaving tradition (Figure 4.20) is an important source of cultural identity as well as a source of income generation for women in the Upper Mustang region. A woman in her mid-20s reflects on how the weaving skill contributed to her livelihood as

> *Mero kheti pati kei pani chaina. Gai bastu haru pani paleko chaina. Ma taan bunne kam garachu. Dherai jasto ma hamro gurung luga haru bunne garchu. Ei bata ali ali amdani huncha. (Household interview, 06/05/2018)*

We do not have farmland and do not practice farming work. We also do not have livestock. I weave our traditional clothes. They are mostly our Gurung clothes such as aprons. I earn a little amount of money by selling them. (Translation, 06/23/2019)

Figure 4.20. Traditional apron in the weaving process in Yara (Source: Autor, Date: June 2018)

Although this tradition is an important practice for maintaining the culture, there are concerns with the money it actually generates for households. A female respondent (50 – 60 years old) mentioned more in-depth about the weaving process and its contribution to her household's livelihood. She said that her income is too low compared to the hard work she devotes to weaving.

Maile yo tan buneko pani dukha dherai chha tara amdani kam auchha. Dinvar dukha garera bunepachhi pani jamma 2-3 pathi khana pugchha. Tyo kamaile 4-5 din lai 2 jana santan lai khana purauna ni dhau dhau hunchha. (Household interview, 06/03/2018)

There is a lot of hard work while weaving. But the income is not reasonable. I have to work the whole day and even days. In return, I only earn money from which I can only buy 2 – 3 pathi (1 pathi = 3.6 KG). It only lasts 4 to 5 days for our just 2 member family. It is really hard to sustain with such minimum income. (Translation, 06/23/2019)

There are some households whose family members participate in various religious traditional work. Participating in religious work helps them in income generation besides what they might generate from agriculture, livestock and wage work. Additionally, this is another form of supporting cultural identity and community cohesion. Both men and women are involved in this traditional system. However, they have to take religious courses as a monk or nun in a monastery to be eligible for this type of work. One such male respondent (30 – 40 years old) shared his adventurous journey of becoming a "*Nakpa*"- a local priest as,

> *Ma 3 barsa 3 maina 3 din dhayn diera baseyo gufa bhitra. Teti bela malai aru manchhe le malai dekhna hudaina thyo. Matra thulo lama haru le matra aera herna pauthyo. Tesai gari bela bela ma ghar ko machhe haru khana purauna authyo. Malai testo garna parne vaeko thyo. Tesari dhyan basnai parne vayo natra ma lama vaera hidna paudaina thyo. Lama vanera ma tyo Dhawa jasto rato luga laera hidna pardena. Hamro "Nakpa" vanchha . Ma tei ho aile. Aile ghar mai basna pauchha. bela bela ma puja ma jane, Gumba ma puja haru garna jane hunchha. (Household interview, 06/16/2018)*
>
> *I mediated in a cave for 3 years 3 months and 3 days alone. During that time no one was allowed to see me. Only high-level religious monks were allowed to meet me. My family members also visited frequently to provide me food. I had to do this as suggested by our religious gurus. Now I don't always have to wear that red dress as a monk. I am called a "Nakpa". I am allowed to stay at home and take part in religious events, worshipping at monastery and local people's home. (Translation, 06/23/2019)*

Traditional income generating activities are also seen partly supporting livelihoods of some households. However, the money earned is too little as said by the previous respondents.

4.5 Livelihood Strategies

As already described in section 1.4.1.4 livelihood strategies are approaches developed and adopted by households to cope in the context of vulnerability, and survive in the adverse socio-ecological environment (Scoones, 1998; DFID, 1999). Primarily, the local people in Yara village are dependent on agriculture for subsistence purposes; this is further supported by animal

husbandry. Agriculture partially supports local people's food requirement, whereas meat, milk, wool are provided by livestock rearing such as goats, sheep, and cows. Besides a subsistence function, livestock (particularly goats and sheep) provide monetary value when they are sold, further supporting household livelihoods and providing for their needs. Wage labor work and various traditional activities are also practiced by some of the households in the village as source of income generation.

For a long time, the natural and socio-political environments have been constantly changing. Moreover, the change is rapid in the last decade and in result, have had different effects on the livelihoods of residents in the Upper Mustang region. Local people reported the changing climate conditions, including drying of available water resources. Further, locals mentioned repeatedly that the exposure of the local community to the outside world and different worldviews and lifestyles is another change since the Upper Mustang's opening to foreign visitors in 1992. Similarly, the development of motor road is also another change in the region that has impacted daily life and economy of locals. To cope with the complexity of impacts caused by natural and social changes, which include both positive and negative outcomes, locals have resourced to adopting various livelihood strategies as described in this section. As identified in interviews, and from observations, five livelihood strategies are being utilized in Yara village: (1) Tourism as an Emerging Livelihood Strategy, (2) Shifting towards Cash Crops from Traditional Farming, (3) Seasonal Winter migration and Trading, (4) Foreign Employment, and (5) Abandonment of Farmland.

4.5.1 Livelihood Diversification: Tourism as an Emerging Livelihood Strategy

Upper Mustang was opened for tourism in 1992; until that, it was a restricted region. ACAP is responsible for regulating tourism activities in the area, including the running of a highly delicate permit system. Each tourist is obliged to pay USD 500 during a stay of ten days in the region and must belong to a group authorized by an authorized trekking agency (Gurung & DeCoursey, 2000; Tulachan, 2003; ACAP, 2010). Initially, at the moment of its launch in 1992, there was a restriction of 200 foreigners per year; however, in six months period in the same year, the number of tourists authorized increased to 1000 (Gurung & DeCoursey, 2000). Upper Mustang now welcomes thousands of foreign visitors every year (Figure 4.21). The statistical report of the ACAP shows that, in 2018, a total of 3946 foreigners visited the Upper Mustang region. Additionally, there is a huge number of domestic tourists visiting Upper Mustang; the number is estimated to be double that of foreign tourists.

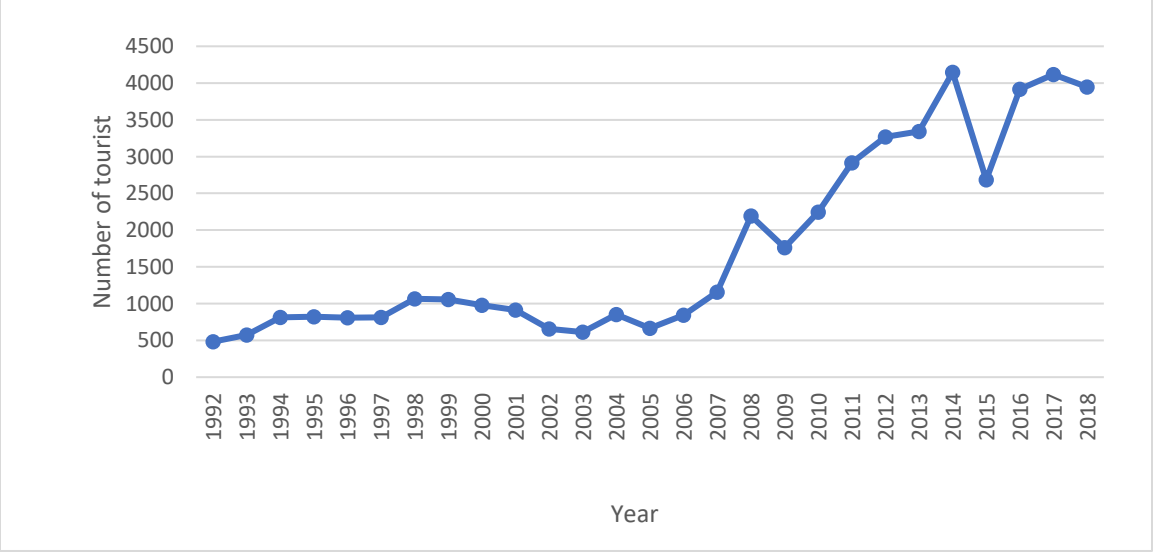


Figure 4.21. Annual trend of tourist arrival from 1992 to 2018 in Upper Mustang. (Source: ACAP)

Tourism has helped diversify livelihoods in Yara, however, only a few households benefit from activities in the field of tourism and are directly involved in tourism. During my fieldwork in

June 2018, four households reported being engaged in the tourism business in the village. Income generated from tourism constituted the major livelihood activity for these households. Locals provide accommodation services through either managed lodges or campsites for tourists visiting the village.

Trekking tourism is the main attraction along with Tibetan culture and various Buddhist religious sites for foreigners in particular while domestic tourists visit Yara primarily for pilgrimage purposes. *Damodar Kunda (lake)*, *Luri gumba (monastery)*, and *Saribung pass* are the major destinations in Yara village (Figure 4.22). *Damodar Kunda* is a major pilgrimage site located at an altitude of 5,000 m a.s.l. (Koirala & Shrestha, 1997; Chetri & Pokharel, 2005). Thousands of pilgrims (Nepali and Indians) travel across Yara village to pay homage to the holy God (Lord Vishnu) in *Damodar Kunda* (ACAP, 2010). The holy trip takes about 2 days through the rugged terrain with frequent steep climbs (based on my own experience). Yara village is also a starting point to Saribung Pass (6,042 m a.s.l), a very popular trekking route among foreigners in the Upper Mustang region; which follows the same path to *Damodar Kunda* and extends across high altitude pass above 5000 m a.s.l. and connects to Manang district, yet another mountainous region of Nepal (ACAP, 2010). Usually, tourists arrive in Yara and stay overnight and travel to *Luri gumba* before beginning their trek towards Saribung pass.

Figure 4.22. Map showing the trekking route to Saribung pass (peak) along with Luri Gumba and *Damodar Kunda* (Base camp in the map) (Source: https://www.peakclimbingnepal.com/saribung-peak-climbing/)

During an interview, one of the households who run hotel services emphasized tourism as their major source of income. Given the rise in tourist arrivals, some households are even expanding their services by adding new rooms. In the following quote, a female respondent explained how they started hotel service in the village. She mentioned how they began with just camping services for tourists when there were no rooms available to completely run a lodge while providing excellent services; they complemented the lodging services with different variety of foods for tourists.

> *Hamro ghar ko mukya amdani ko srot vaneko nai lodge ho. Hamile yo lodge suru gareko dherai aagadi dekhi ho. Purano ghar ko agadi chaur ma camping garthyo. Ani tea house banayo ani bistarai . Pooja kotha ma sutane gartyo tourist lai .Ani guide harule sikayo room haru banaunaunu, hotel ko menu banaunu ani pachhi ya mathi ghar banako . Paila hotel suru garne hami nai ho. Camping garthyo paila.*

Ani hotel suru garepachi hamro hotel ko name pani saribung rakhyo. Paila vanda aile tourist haru aune badi cha. Paila home stay matra thyo tara aile thulo lodge haru banauna thalyo. Ra tourist haru pani badi auna thalyo….. Season ko bela dherai ramro chalchha. Tourist haru auchhan ghumna. tesai gari off season ko bela ma pani auchha tourist haru. (Household interview, 06/18/2018)

Our major source of income comes from our lodge. We are the first household to begin lodge service in this village. In our starting days, we only had camping site and a small tea house. We did not have rooms for tourist. They used to camp outside on the ground nearby our old home. Some could manage to sleep on the floor in our small room. As the number of tourists kept on increasing, the guides suggested us to construct proper rooms and provide good food for tourists as they demand. So, we decided to build new house. We made this house where we are right now. We named this lodge "Saribung lodge". Saribung is a pass in the north of our village. We have seen increase in number of tourists in recent years. We get plenty of tourist in peak season. The number of tourists is still good even during off season. (Translation, 07/02/2019)

Camping along with trekking is one of the favorite travel activities among tourists. However, according to one female respondent who participates in the tourism business, there have been changes in visitor's lodging preferences. She said tourists who visit Yara village nowadays seek for comfortable rooms rather outdoor camping.

ma hotel chalaune garchu aile. Paila camping ramro chalthyo. tara ajabholi camping audaina. aile room ma basna lai matra khaire haru aucha. tesaile hamile pani aile room thapdaii chau hotel chalauna ko lagi. Tourist haru ko sankhya baddai gakole hamile room haru banauna lageko ho. (Household interview, 06/04/2018)

I run a hotel. Camping was preferred by tourists in past. However, nowadays tourist wish staying in well-established room. Therefore, I decided to add few rooms. Construction work is going on right now as you can also see. There has been increase in number of tourists visiting Yara village recently. (Translation, 07/02/2019)

Tourism is solely the major source of income for those four households. These households were extremely positive about the increase in tourist numbers and the potential of tourism in the village to further develop. As a result, they were expanding the scope of their services. Besides households proving lodging services, there were six households who were involved in tourism

activities and getting some benefit by providing horse services to visitors. This type of transportation activity partially contributed to income generation for those households. Tourists would prefer to hire horses over walking when they visited *Luri gumba (monastery)* situated an hour away from Yara village. Locals are paid NRS. 1500 (15 USD) for the horse services. The following quote is from a male respondent in his 40s who describes how he and other households in the area have managed to earn money via providing horse services to tourists.

> *Aile yesh Yara gauma manchhe dherai auna lageko chha jastai tourist haru. Hotel hune ghar harule ramro amdani garne gareko cha. Tesai gari hami hotel navaeko haru le ni amdani huncha. Jastai tourist harule hamro ghoda haru chadna khojcha. Dherai jaso luri gumba jana ko lagi ghoda laijancha. Hamile din ko 1500 ma bhada ma dinchau. (Household interview, 06/10/2018)*
>
> *Nowadays, more people are coming in our village. Among them most are foreign tourist. Households who run hotels make good income out of it. However, households who do not have hotels, like me, also make money sometimes. Such as when tourist want to go to luri gumba, they like to hire our horses. We get around 1500 rupees ($15) for a day. (Translation, 07/02/2019)*

In Yara, tourism is increasingly becoming an important livelihood option as a primary activity and a supplemental livelihood strategy. Even though tourism has brought opportunities in the village, there are some drawbacks as well. One of such drawbacks is lack of proper waste management which has resulted in increased pollution in the village. The following quote by a key informant (male aged 40 -50 years old) from Yara school which reflects this problem.

> *Paryatan ta ramro vaeko cha gauma. Gaule ko amadani ko srot vaeko cha. Tara phohor ko byawasthapan ramro huna sakeko chaina. Jata payo tetai phohor falne chalan cha, jastai bottle haru, anya phohor haru. Esle garda bato wara para pradushan vaeko cha. (Key Informant Interview, 06/14/2016)*
>
> *Tourism has brought opportunities in the village as an income-generating source. But, produced waste has not been managed properly. Locals are seen throwing garbage in random places, mostly bottles and others. As a result, pollution has increased in the village, mostly around walking trails. (Translation, 07/25/2019)*

4.5.2 Agricultural Extensification: Apple Farming

Apple farming (Figure 4.23) was described as a new livelihood strategy by locals during interviews. There were five households who mentioned having apple orchards in their farmland; however, in its initial stage currently. These households were optimistic about the opportunity of income generation once apple trees are fully grown up produce fruits. The following are quotes by local people; a male respondent of age 30-40, and another male respondent of relatively old age in his 50s.

> *Mero 15-20 wata syau ko bot lagako chha. Khas 8- 9 barsa ma ali ali falcha. Aba 15 barsa pugepachi fal ramro hunchha ra 40 barsa sama fal didai janchha. Kunai ta biruwa ko anusar ho. Kunai ta yo sal ropyo vane yo sal nai fal dinchha ra marera janchha……aba paila ta yeta tira Syau hunethena jado le. Tala tukche, marpha ghasa jomsom tira ropthyo. Aba tei change hudai janchha aja bholi haina. Aba eta tira tato bhayo ra syau pani hudai gayo, pheri ghasa tira chai syau hudaina ra bistarai tyaha suntala ropchha ra ramro hudai janchha. Aba eta tato aepachi syau hune ra tala chai syau utpadan kam vaera suntala hunchha. Aba Jomsom vanda mathi ta syau ropna lako dherai barsa vaisakyo ….Aba tei ta ho, paila ekdam jado huntyo aba aile hiudo maina bhari thikai chha hiu pardena tato vaechha. Tei anusar le yo thau ma paila syau nahune thyo aile hunchha. Hamile pani aru kheti chhodera syau kheti tira lagdaichha. (Household interview, 06/12/2018)*
>
> *I have planted 15-20 apple trees. Apple trees grow in 8 to 9 years. They start giving fruits when they reach 15 years and last until 40 years of age. But it also depends on the type of apple. Some species give apple in a year of plantation and they die immediately after harvesting……apple did not grow in this region in past due to cold weather. It was only planted in Lower Mustang in Tukuche, Marpha village. But now change is happening, temperature increased here, and apple started to sustain here. But now in Ghasa village, apple does not grow rather oranges grow there. Now due to increase in temperature apple farming is possible here and in lower region orange plantation will replace apple farming. Well, apple farming has become possible in village north of Jomsom. It has been several years now. Well, actually it used to be really cold here in past. Nowadays we do not get much snowfall in winter. As a result, apple started growing in this region which was not possible in past. We are now shifting towards apple farming rather than planting other crops. (Translation, 07/02/2019)*
>
> *Aile sau ko bot haru lagaeko chha testai 10-12 ota jati . 2 barsa jati bhayo lagaeko. Paila Lower Mustang ma sau marpha bata launa suru gareko hore. euta solukhumbu ko sherpa le jammu kasmir bata biu laera cross garera naya sau haru lagauna suru gareko ho. hamro mustang ma local sau haru ta dherai chha. tara pachhi cross garera jhan bikasi sau haru utpadan garna suru gareko*

ho……Yaha Yara gau ma sau paila dekhi hune raichha manchhe harule naropera matra ho. (Household interview, 06/17/2019)

Now we have planted some apple trees like 10 -12 in total. It has been just 2 years. In past, apple plantation was started in Lower Mustang in Marpha village. A Sherpa form Solukhumbu brought some apple trees from Jammu Kashmir in India and started planting in Marpha. We also have our local species, but people started bringing hybrid species and started planting different varieties of apple……. I think apple plantation was possible in the past too, but people never tried to plant it before. (Translation, 07/02/2019)

Figure 4.23. Apple farming in Yara (Date: June 2018, Source: Author)

The first respondent mentioned about the timing and the number of apple trees he has planted. He further described the species and its time of harvest. He also referenced the latest apple farming trend in Upper Mustang, which had previously been impossible because of colder weather conditions. In the second quote, the respondent discussed the evolution of apple farming in Lower Mustang. He also added his thought about the possibility of apple farming in Upper Mustang in the past, which people thought they could not and had never tried before. He did not link it to changes in weather conditions, but rather said people not trying to plant apple trees in the past.

When asked about the recent trend of apple farming in Upper Mustang, a key informant (from ACAP office in Jomsom) linked this to the phenomenon of vegetation shifting in Mustang. He said there was a shift in vegetation patterns into higher areas as these fruits began to adopt in the region where they used to be absent. He also mentioned about the decrease in apple quality in Lower Mustang, which in the previous years was considered to be the finest location to produce quality apples; linking it to untimely snowfall in Mustang. He further suggested the possibility of apple growth in Upper Mustang region could be because of the shift in the timing of snowfall and increased warmness in the region.

> *Aba esto cha vegetation shifting ko kura lai ya jodna sakincha. Tulanatmak hisab le herda last 30 years ko comparison garda tala Ghasa ma syau phalthyo tara aile suntala falna thalisakyo ghasa ko chheu chhau ma. Ani Marpha lai chai syau ko pakad chhetra ra tya ko syau ekdam mitho hune vaninthyo tara aile Chhuksang ko sau marpha ko vanda mitho huna thalyachha. Tesko matlab vegetation shifting Mustang ma pani dekha pareko chha. Esko karanle chai esto vaeko huna sakcha…. Mustang jilla ma paila hijoko din ma samaya ma hiu parne, hiu paryapta matra ma parne garthyo, tara aile chai hiu ko tyo pattern lagatar 3 barsa yata ko pattern herda chai timing shift vaera gai raakheko dekincha. Push magh ma hiu nai parna chodya cha vane Falgun, chait, baisakh ma hiu parna thaleko cha… Tei vaeko huna le pani yo snowfall ko pattern change vaeko hunale garda Marpha ko syau ko productivity ra esko taste ma change aeko huna sakcha. Arko tira jado kam vaeko hunale ra syau lai chaine tapkram yaha aile vaeko le pani yaha syau kheti sambha vaeko huna sakcha. (Key informant Interview, 05/30/2018)*

> *Well, we can say that it is because of vegetation shifting in this region. If we see the trend in the last 30 years, people used to grow apple in Ghasa (a village in lower Mustang). But now, people are growing oranges there. Similarly, Marpha (another village in Lower Mustang) is considered as the place producing good quality apple but nowadays apple grown in Chhuksang taste better than in Marpha. This means the vegetation has been shifting to a higher altitude in Mustang. That could be one reason for the growth of apple here [in Upper Mustang] ….Mustang region used to get enough snowfall in a timely manner in the past. But if we look at the pattern of snowfall in the last three years, there has been a shift in its timing. Snowfall does not occur in December-January nowadays it has rather shifted towards February to April. Change in timing of snowfall might have affected the quality of apple in Marpha. On the other hand, due to decreased coldness [in Upper Mustang], the*

temperature could have favored apple growth. This could be the reason for the possibility of apple growth here. (Translation, 06/25/2019)

Locals in Yara have considered apple farming as a new livelihood and income generation strategy. People are moving progressively from traditional local farming to cash crop like an apple plantation. However, if we look back on the past, the region has not had this kind of practice. Some locals and key personnel suggest that the warming trend is the key reason for the recent growth in apple. While some people said they never attempted it before. Nevertheless, the declining pattern in the Lower Mustang region, while increasing production possibility in Upper Mustang, indicated that the climate played a role in the process.

4.5.3 Migration

Migration is also one of the major livelihood strategies practiced by locals mainly in the form of seasonal winter migration and foreign employment.

4.5.3.1 Seasonal Winter Migration and Trading

As described by the local people, winter migration is a key livelihood strategy and an opportunity for income generation with people engaging in various seasonal businesses. After harvesting of wheat in September local people start to migrate to southern regions in Nepal and stay there for three to four months. Locals mentioned there are two types of migration destinations: to India and to Nepal. The first kind of migration includes going to cities in India such as Banaras, and Assam to take part in seasonal businesses. People install temporary shops where they sell garments, mostly sweaters bought from Ludhiana city in India; several Yara households owned their own trading business. Various respondent mentioned working (wage labor) at shops of well-off households. The following quote is by a female respondent in her 30s as she shared her experience working at the winter market in India.

Hiudo ma byapar garna India ko banasar pugchhau. Dashain sakepachhi hami tala jharchhau. Testai teen maina jati byapar gari baschhau. dui maina jati byapar garchhau. Ra baki raheko ek maina ghumgam ra afanta bhetghat garchhau. Hamro afno byapar haina tara aruko byapar ko kam ma hidne garchhau. Tei bata jyala line garchha. (Household interview, 06/11/2018)

In winter, I go to Banaras city in India for winter business. After Dashain festival is over, we descend down. We do business for about three months. Out of those three months, we do business for two months and remaining one month we spend visiting our relatives. Well, this business is not mine. I work for other people. We take salary for working at their shops. (Translation, 07/03/2019)

The other kind of winter migration takes place in the southern cities of Nepal, such as Pokhara and Kathmandu. Locals mostly mentioned working as street vendors where they sell garments and various medicinal plants; they are mainly females. The following quotes are by three local female respondents in their 30s describing winter migration and practicing seasonal business to make a livelihood. The third respondent emphasized how the income generated from winter business is used to buy foods for the time when they return back to the village after winter is over.

Hiudo ma byapar garna hami pokhara kathmandu tira janchau. Teha jimmu, luga haru ko byapar garchau. (Household interview, 06/05/2018)

In winter, we go to Pokhara, Kathmandu for seasonal business. During that time, we sell clothes, jimmu (an herbal plant used to flavor curry, pickles, and lentils). (Translation, 07/03/2019)

hiudo ma tala byapar garna janchhau. Pokhara samma janchhau. Jimmu, ra aru luga phata ko byapar garchhau. (Household interview, 06/06/2018)

We do seasonal business in winter. We go to Pokhara to sell jimmu, and other clothes. (Translation, 07/03/2019)

Hiudma byapar garna pokhara janchhau. Jimbu, sio dhago, ani kapadako byaparr garchau. Ali ali amdani hunchha tyabata. Hami hiud ma byapar garchha ani tei paisa le barkha ma rasan kinera lae khanchha. (Household interview, 06/09/2018)

We go to Pokhara in winter. We sell jimbu, clothing needles and cotton threads, and other garments. We make little money out of it. We buy foods from income generated from winter marketing for the time we come back after winter ends. (Translation, 07/03/2019)

Winter migration has partially helped local residents generate revenue while meeting household needs and demands for food. Furthermore, it's a major strategy for adapting to the harsh winter weather while temporarily moving to a warm region in southern Nepal (Jackson, 1984; Tulachan, 2003; Pokharel, 2009).

4.5.3.2 Foreign Employment

Currently, locals have also started seeing opportunities working abroad. But the trend in foreign jobs is relatively recent, with more people being educated; mainly young people. A total of three individuals (two men and a woman) from three separate households were working in a foreign country to support livelihoods for their household (Household Interview, June 2018). The following quote is by a female respondent (40 - 60 years old) mentioned her daughter working in France. She further elaborated upon the cost of sending her daughter abroad and how she managed to cover the cost while taking a loan from the bank. However, she was unaware of the earning of her daughter and could not provide the exact figures during the interview.

> *Mero chhori euta france gaeko chha. Uslai bank bata rin garera gaeko ho testai 22 lakh jati lagyo. Chhorile paisa pathaucha ra aile bistrarai rin tirdai chhau. (Household interview, 06/06/2018)*
>
> *My daughter is in France now. We had brought loan from a bank to cover the cost. It cost around 22 lakhs (22000 dollars). Daughter sends money and we are slowly paying the debt now. (Translation, 07/03/2019)*

Another female respondent (30-40 years old) further described the younger generation's attraction towards foreign employment. According to her, since the young population is educated nowadays, they seek for better opportunities outside of their village. While searching for the best options (other than traditional income sources), some chose to go to foreign countries for work. She also added how people are abandoning the local village work and leaning towards modern work opportunities in cities and in foreign places as well.

> *Tesai gari yuwa haru pani dherai padne vanera tala sahar jancha ajakal. Ani padhai sakepachi ramro kam ko khojima aile bidesh tira pani jana thalyo. Paila ta padne vane hunethena, gau mai kam matra garne garthyo. (Household interview, 06/18/2018)*
>
> *Similarly, the younger generation now go to cities for education. After finishing the studies, they look for better jobs. In search of jobs, they even go to foreign countries. In the past, people never really got educated, they were only involved in local household works in the village. (Translation, 07/03/2019)*

As the above respondents stated, young people from the village, in particular, are looking for possibilities outside of the village. Better education could have resulted in a trend that in past years had not been in practice because of people's lack of education. In addition, the local traditional income generation methods have become increasingly inadequate to support a household. As a result, people are seeking for opportunities while going as far as to foreign lands.

4.5.4 Abandonment of Farmland

> *Upper Mustang was always dry. It was a gift of the Kaligandaki River. Like Egypt is the gift of Nile River. So, water is a source of life. And that is why the holy mountain in Upper Mustang is the source of the Kaligandaki River. People know about the relationship between water and life. Because if you see agriculture here, everything depends on irrigated water. There are very small patches around the villages which is they make fertile. It is not made automatically. They had to build farmland. They had to protect the land from the constant wind as well. So, it is very very hard living condition in Upper Mustang ever. But nowadays if I compare it to 1992, it has become more worse because of the global climate change (Key informant interview, Male, 50-60 years old)*

As described in the above quote, the geography of the Upper Mustang is really harsh, with very limited rainfall. Fertile land is very scarce. People have turned desert-like fields into fertile land with continuous hard work for hundreds of years. They have protected the farmland from the wind with walls and provided water through irrigation. However, local people reported a continued decline in water in *Puyung Khola (river)* in recent years. As the water sources are drying, people are slowly abandoning their farmlands (Figure 4.24). They are left with no other option rather than

just giving up on what they were doing for several years. The following quote is by a male respondent as he points out abandoned farmland across the *Puyung Khola (river)* to the other side of the village and recalls his memories from the past when the local people used to cultivate the patches of land as they had plenty of water for irrigation. Now, the water crisis is looming. As a result, they are forced to leave those once-fertile lands to become a deserted land.

> *Pari dekhnuhuncha tyo jagga haru sabai ma kheti bali lagauthyo. ahile paniko samasya le uta sabai ropna chhadyo. Tyaha pratek ghar ko 1-2 ropani jagga chha tyaha. 14 barsa jati bhayo tya bali launa chhadeko. (Household interview, 06/17/2018)*
>
> *As you can see across the river, we used to cultivate those lands in the past. But now due to lack of irrigation water, we have abandoned those lands. Almost every household from the village has some piece of land there like 1-2 ropani (~ 508 Sq m). It has been around 14 years now since those lands are left uncultivated. (Translation, 07/03/2019)*

Figure 4.24. Google Earth image showing abandoned farmland (in blue) in Yara (Source: Google Earth Pro, date accessed: 07/23/2019)

During household interviews, every household respondent mentioned land abandonment and identified a lack of irrigation water as a major reason for doing so. In the following quote, a

male respondent aged 40 – 50 years old mentioned there was plenty of water in the past for irrigation while showing me the remnant of an irrigation canal during the interview.

> *Paila uta paari dekhnuuncha pari kati khet chha. Tya paani napugera aile sabai bajo nai chha. Paila paani pugthyo teha khola bata laera lauthyo. Tara aile paani sukdai gayo ra bistarai pariko jagga khali bajo chodai gayo. (Household interview, 06/10/2018)*
>
> *As you can see on the other side, it was all farmland in the past. It is all left fallow now due to lack of water. In the past, there was plenty of water. We used to bring water from the river. But now the river has dried, and we have left those lands fallow and do not cultivate now. (Translation, 07/03/2019)*

People cannot grow crops even if they have plenty of land available. For more than three decades, water scarcity has been a significant limiting factor and every year it is getting worse. The available arable lands have declined, and production has decreased. As a result, people are abandoning their lands while looking for other livelihood activities. Moreover, two villages in Upper Mustang; Samzong and Dheye, which are not far away from Yara have recently relocated to a new place due to acute water shortage in the village. The people of Yara should, therefore, attempt to find a solution to the shortage of water in order to avoid such relocation.

4.6 Livelihood Outcomes

The sustainable livelihoods framework has identified five indicators to represent the desired livelihood outcomes – (1) reduced vulnerability, (2) more income, (3) improved food security, (4) increased well-being, and (5) more sustainable use of natural resources. However, based on the context, the available assets, the transforming structures, access to livelihood resources, and the ability to apply various livelihood strategies vary and the resulting livelihood outcomes could deviate from the outcomes indicated by the sustainable livelihood framework. In this section, we highlight the livelihood outcomes that have resulted in the area; these are described

using the five indicators from the livelihood framework- vulnerability, income, food security, well-being, and use of natural resources mentioned above.

4.6.1 Vulnerability: "Living on the Edge"

Given the ongoing changes, various factors have played a significant role in the vulnerability of Yara village and its residents (Figure 4.26). The geology of the village is extremely vulnerable to active landslides and soil erosion with fragile soil structure (Figure 4.25). As mentioned by local people, farmlands and houses are prone to rotational and translational landslides. During fieldwork, numerous damaged houses, which were abandoned could be seen. Yara village's vulnerability to landslides was also noticeable during observation. A study conducted by Bernet et al in 2012 also reported the vulnerable condition of Yara village by an active deep rotational landslide. They estimated a few centimeters of an associated movement per year while linking such acceleration to severe rainfall events.

Figure 4.25. Fragile land structure of Yara village (Date: June 2018, Source: Author)

Erratic and extreme rainfall is another factor to further exacerbate the vulnerability as it triggers landslides and flash floods which resulted in the destruction of village resources – houses, irrigation canal, and farmlands. Drying of water resources is also a problem which is directly impacting the daily livelihood of locals. With just one working tap in a precarious condition, scarcity of drinking water is a major problem for local people, forcing locals to collect water from the river and local wells when the only working water tap dries frequently. Every year, locals struggle to irrigate the available farmland with little water available. Moreover, the ongoing subsurface loss of water still exists, and locals are totally reliant on traditional ecological knowledge to mitigate the loss.

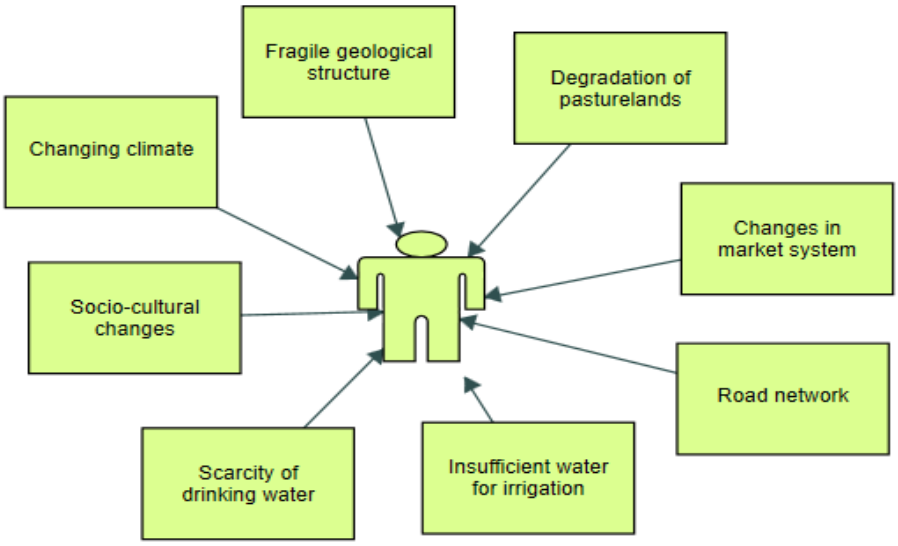


Figure 4.26. Diagram portraying vulnerability in Yara

Locals are heavily reliant on rangelands to feed the livestock. Declining snowfall and shifting in the pattern of snowfall has been a major concern for locals in Yara, as it directly impacts the growth of grass in rangelands. Additionally, the increasing impact of winds is also another factor attributing to the vulnerability of the local population and the resources.

The motor road has contributed to the easy accessibility of the village while helping them in the supply of foods and goods from the market. Improved communication system and improved educational opportunity have also come along with it. However, with increased accessibility and infrastructure development, locals are modernizing and changing their lifestyle. With roads and new technologies have redefined the connection of locals to the outside world. In a nutshell, globalization in the area is also a growing threat to local culture and tradition, which was completely untouched in the past.

Given the fragile geological structure, Yara's vulnerability to landslides and flash floods is likely to increase in the future (Bernet et al., 2012) which is further exacerbated by the changing pattern in climate. Additionally, Yara's rapidly changing socio-economic structure could alter the indigenous livelihood completely into a modern one. While the sustainable rural livelihood framework has identified reduced vulnerability as a livelihood outcome, in the case of Yara village, the situation could even get worse.

4.6.2 Low Income: "Seeking for New Ways of Income Generation"

Figure 4.27 illustrates the available sources of income for locals in Yara. The major source of income is very limited and mostly comes from agriculture and animal husbandry. The nature of agriculture is completely subsistence-based which fulfills the needs of a household only for about six months. Additionally, agricultural production is solely dependent on irrigation water, which is very scarce as the water sources are drying up in the region. One of the major income-generating sources is from animal husbandry which is also at stake with the degradation of rangelands. As a result, the cost of raising livestock is increasing as most of the diet needs are supplied from the market.

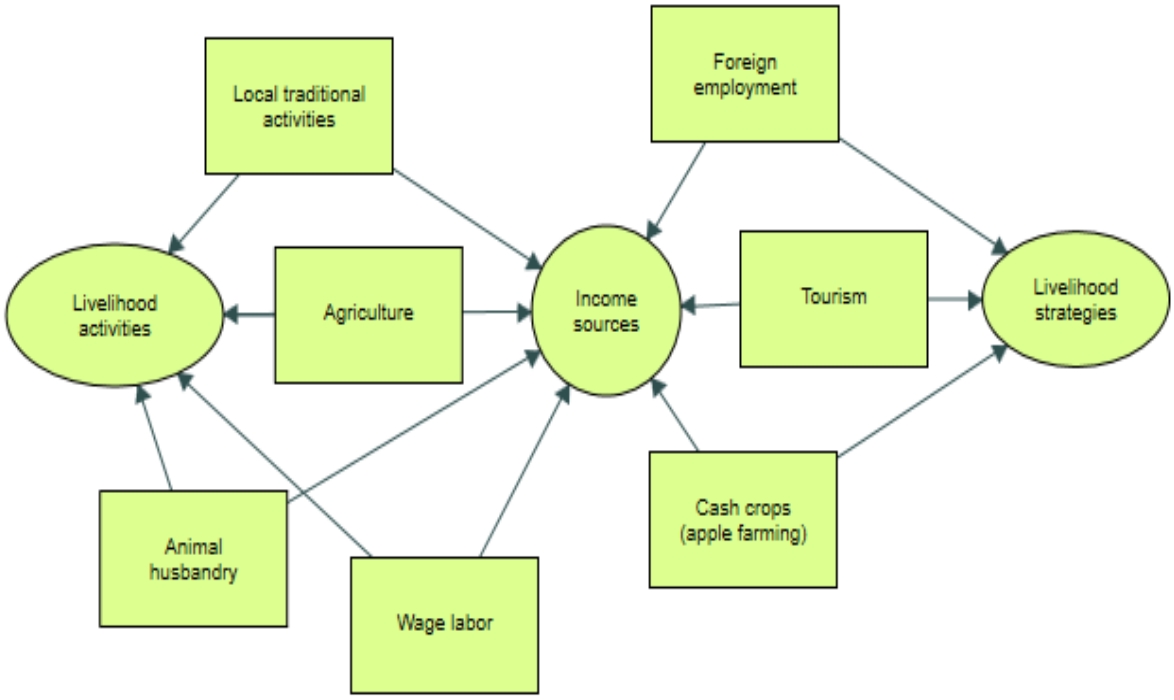


Figure 4.27. Income generation sources as represented in terms of livelihood activities and strategies

Tourism is perceived as an effective livelihood strategy in the village. Some households were involved completely in the tourism business running lodges and hotels whereas many of the households who owned horses were also generating income by providing horse services to seasonal tourists. Similarly, local people have started cash crop production such as apple farming instead of traditional crops. Locals anticipated apple as a source of future income generation as having just panted trees and which take around 10-15 years to mature and produce fruits.

Other income-generating activities included winter marketing in cities of Nepal (Pokhara, Kathmandu) and India (Banaras, Ludhiana, Assam), which is practiced by more than half of households. Daily wage labor work in construction, weaving, and the selling of local garments, and paid labor work in agricultural activities were other sources of income generation for mostly

poorer households. Some of the household members are involved in foreign employment. However, it is just a recent trend which was absent in the past due to lack of education as described by local people.

The livelihoods of locals in Yara is dependent on subsistence-based agriculture, animal husbandry, and seasonal income businesses. The incomes generated by these practices do not fully meet the local people's requirements of foods and other essential goods. Additionally, various social, as well as climatic factors, are driving local's livelihood to alteration. However, in recent years, locals are diversifying their livelihood through various income-generating activities such as tourism business, growing cash crops, and with some households' members involved in foreign employment.

4.6.3 Food Security is at Risk

Local people fulfill their food needs from various sources which include local farm products, livestock products, and market (Figure 4.28). Even though most of the households are involved in farming that alone cannot fulfill the food needs of local people. A single cropping season, limited arable land, and a lack of irrigation water are major limiting factors of food production in the village. Locally produced crops mainly wheat, potato, and some green vegetables are insufficient to meet dietary needs beyond five to six months. As a result, local households have to buy food mostly from the market. Local people mentioned their heavy dependence on the Tibetan market for bringing Chinese food products to fulfill the food need in the past, which is still prevalent. However, with the completion of motor roads in the Upper Mustang region, most of the food and other household goods are transported from southern cities of Nepal. Currently, markets at both places are serving to fulfill local's need.

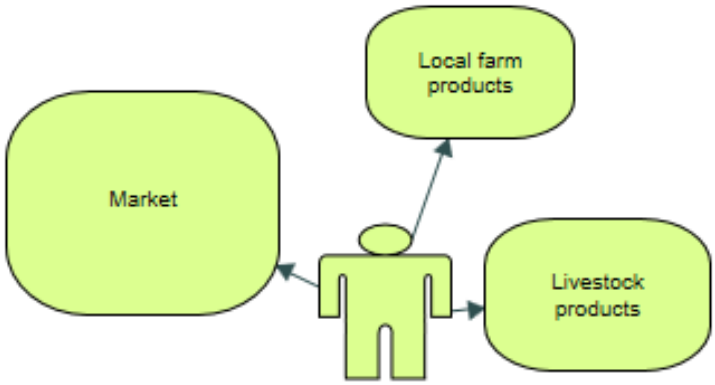


Figure 4.28. Available sources to meet food needs for locals in Yara (Size reflects the dependence level)

Local people have been practicing multiple livelihood strategies to meet their food requirements. Agricultural production fulfills the food need partially as such most food requirements are met by marketed goods. Animal husbandry is another major source which provides foods in the form of meat, milk and dairy products. Locals also practice winter migration and involve in seasonal businesses for income generation; which supplements to fulfill required food needs. However, in Yara food security remains at risk, even with all these strategies.

4.6.4 Improved Well-being, but Not for All

I observed differences in household well-being statuses in terms of possessing a house and farmland. Similarly, the number of livestock also differed among households. The ability to diversify livelihoods was another key aspect to determine the sustainability of the household. Various factors such as land holdings, income sources, education, access to assets, and food security determine the well-being of a household (Figure 4.29). Some households are highly

diversified having access to various livelihood strategies whereas there are some households who are solely dependent on daily wage work for making their living. Thus, the well-being status is greatly determined by the income generation of households.

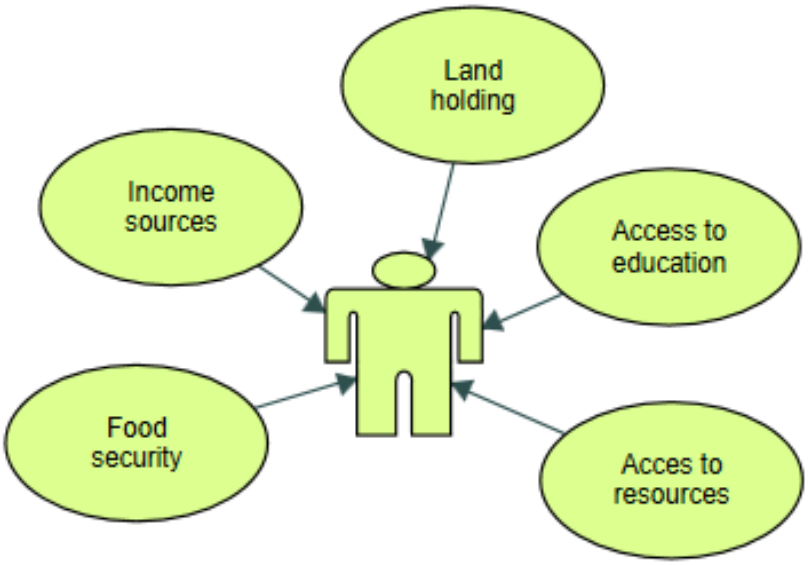


Figure 4.29. Diagram showing determining factors of well-being

Education of children is mostly supported through sponsorship from foreign donors. Tourism has brought opportunities for local people while providing various income generation activities. However, as one of the male respondents from Yara village quoted, the "rich are becoming richer while the poor are becoming poorer." Not all households are getting the benefit of income generation from tourism as only well-off households are able to thrive in the tourism industry.

4.6.5 Use of Natural Resources - Is it Sustainable?

Most of the livelihood activities in Yara village are dependent on natural resources (Figure 4.30). For instance, local people take their livestock to rangelands for grazing. During household

interviews, local people frequently mentioned the increasing trend of rangeland degradation. According to them decreasing snowfall in winter and less rainfall in summer were the major causes. However, an increasing number of livestock could also be one reason for rangeland degradation which was not the concern for local people as they did not really realize it during interviews. Based on the household interviews, we recorded an increase in the number of livestock owned by households in the village. There were 1,775 goats/sheep, 46 cows, and 29 horses owned by a total of 16 households according to household interviews (As of June 2018). In 2012, Bernet et al (2012) reported 1,301 goats/sheep, 31 cows, and 29 horses. By looking at the records of livestock between 2012 and 2018, we can clearly see the increase in the number of goats/sheep and cows. Rangeland degradation could therefore partially be caused by some anthropogenic factors as well. Chapter 5 covers the biophysical aspect of this study where we utilized remote sensing to monitor the changes in natural resources; vegetation in rangeland and permanent snow cover. We also studied the impact of climate change in rangeland. Additionally, we studied the anthropogenic impact on rangeland in the entire Upper Mustang region and in Yara village.

Local people reported the acute scarcity of irrigation and drinking water. Drying of water source and constant water loss due to seepage was reported owing to the water shortage. Similarly, declined snowfall and rainfall were also mentioned, which might also have caused the reduction of water sources. Every year, a certain amount of budget is allocated by the government as well as ACAP for maintenance water resources. However, according to local people fragile soil structure, landslides, and flash floods frequently have destroyed irrigation canals and drinking water pipes.

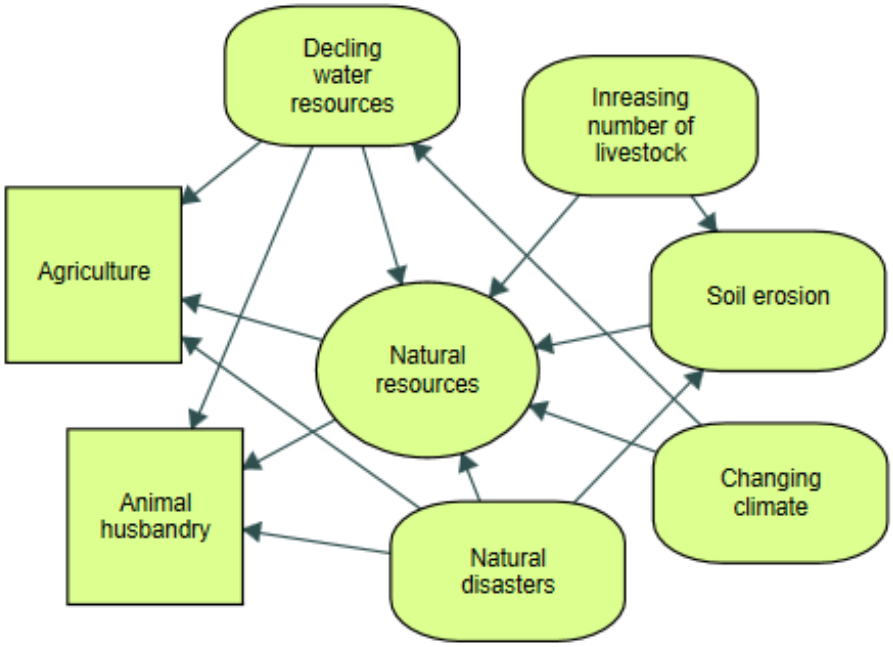


Figure 4.30. Diagram showing nexus of natural resources

Additionally, a lack of quality in the irrigation system was reported and locals were extremely unsatisfied with the maintenance work as well. There were many such voices in which one could clearly hear the level of frustration. The following quote is by an elderly female respondent which represents many of those voices.

> *Khanepani, sichai ko lagi marmat vanera barsai pichhe sarkar bata sahayog ta auchha. Manchhe lagaera thekka ma marmat ko kam garchha tara khai k garchha. Samasya samadhan vaeko chhaina. Kam ramro sanga nagarya ho ki . hami gaule le ramro sanga anugaman navaera hoki. (Household interview, 06/06/2018)*
>
> *Every year the government allocates budget for maintenance of irrigation and drinking water system. We hire people in contract for the work. But the problem is still the same every year. Perhaps it is because people do not work properly or perhaps, we villagers are also not observing their work properly. (Translation, 07/06/2019)*

5. Concluding Remarks

In Yara, local people are involved in multiple livelihood activities while utilizing available resources. Agriculture and animal husbandry are two major activities. However, agriculture is subsistence-based in the region and only partially meets food needs. Animal husbandry is practiced by half of the households in Yara; it supports local dietary needs by providing food, milk, and also a good source of income through the sale of livestock. Locals also practice wage labor for income generation, which is most prevalent among poorer households. Likewise, some households participate in local traditional income-generating activities. All these activities, however, do not entirely support local needs; as such people are dependent on the market for most of the food requirements and supply of goods.

Yara village and its inhabitants are extremely susceptible to fragile geography often impacted by landslides and flash floods. Soil erosion and the harsh wind are prominent in the region. Furthermore, changing climatic conditions are also exacerbating local vulnerability. For instance, according to locals, a decline in snowfall and a shift in timing have caused changes in grass availability in rangelands. Available water resources for irrigation are drying, which has increased food insecurity. The water loss due to sub-surface flow in the river is a major obstacle for locals while regulating water for irrigation. Moreover, because of the absence of water, locals are forced to abandon farmlands. Scarcity of drinking water is also a big problem; the village has only a small amount of water available and the source of drinking water is also in critical condition with the drying of water. Rainfall is limited in the region. Additionally, the erratic and extreme rainfall has been observed in recent years by locals.

Given such stressful conditions, locals are diversifying their livelihoods through various income generation activities. Since 1992, tourism is increasingly becoming popular as the Upper

Mustang opened for international visitors. As such, some households in Yara are involved in the tourism business by running hotels. Other households have benefited through seasonal income from tourism through horse rental services to visitors. Locals are also attracted towards cash crop production mainly apple farming; this activity is perceived as a good source of income. Some locals are working abroad, and this is also seen as a potential revenue source. However, considering the household's well-being, the capacity to diversify livelihoods between households varies.

Road development has been a blessing for locals, as it has helped them to travel and transport necessary goods from the market for which they had to walk or rely on horses in the past. However, as a foreign tourist in the region mentioned, the road has affected trekking tourism in the region (Key informant interview, 06/14/2018). As a matter of concern, this issue has been recognized by ACA, which has begun to develop alternative trekking routes (Key informant interview, 05/30/2018).

As expressed by locals, given current natural and social shocks and conditions of vulnerability, locals have pursued different adaptation strategies and have implemented different livelihood strategies, even given limited resources. But the livelihood outcomes of locals in Yara are not sustainable while attributed by existing food insecurity, poor income and varied well-being conditions among households. Various factors, such as fragile geology, water scarcity, declining grass in rangelands and changing climate are further exacerbating the current vulnerability. The limited available natural resources in the village is also another driving factor contributing to the vulnerability of Yara and thus affecting the livelihood outcomes.

In light of the vulnerable situation, the assets available to support local livelihoods are not enough. Natural assets like rangelands, agricultural areas and water resources that strongly help the livelihoods of local people are decreasing. Locals still rely on traditional adaptation strategies

for management and use of resources that are not effective in the present context. However, local traditions and norms are an important element which directs the everyday lives of local people in the village.

CHAPTER 5: QUANTITATIVE BIOPHYSICAL ASSESSMENT

5.1 Introduction

The rangelands (Figure 5.1) occupy about 40% of the Upper Mustang region (Chetri & Gurung, 2004; Paudel & Andersen, 2010); they are considered critical ecosystems that provide numerous goods and services to local people including freshwater, fuelwood, a wide variety of bio-resources, and opportunities for recreation and spiritual replenishment (Dong et al., 2009; Aryal et al., 2013). Rangelands also provide habitat for wildlife, preserves soil and help regulate the climate (Dong et al., 2009; Ning et al., 2013).

Figure 5.1. Rangelands in Yara situated above 4,000 m a.s.l. (Date: June 2018, Source: Author)

As livestock rearing is one of the major livelihood activities in Upper Mustang, local people use rangelands primarily for grazing (Tulachan, 2003; Basnet, 2007; Paudel & Andersen, 2010). The fodder resources of the highland rangelands are essential for sustaining livestock. Rangelands are also important to conserve water and regulate flow to downstream areas. The agriculture

system in Upper Mustang is highly dependent on irrigation. The water for irrigation is regulated by water resources in the rangelands mostly accumulated by the seasonal snowfall and high-altitude glaciers.

Designated as a part of the Annapurna Conservation Area (ACA), the rangelands of Upper Mustang are home to diverse flora and fauna. Plant species such as *Caragana spp., Lonicera spp., Stipa spp., Carex spp., Kobresia pygmaea* (C.B.Clarke), *Kobresia felicina* (C.B.Clarke), *Lagotis spp., Thymus linearis* (Benth), *Corydalis spp., Delphinium spp., and Meconopsis spp*. characterize the rangelands (Chetri & Gurung, 2004). Areas below 4,100 m a.s.l. are dominated by shrub species such as *Caragana spp., Lonicera spp., Stipa spp., and Rosa spp.* Between 4,100 and 4,300 m a.s.l. a mixture of alpine grassland with dwarf shrub is found, which mainly comprise *Thymus linearis* (Benth), *Delphinium spp., and Meconopsis spp*. Whereas areas above 4,300 m a.s.l. are dominated by alpine grassland such as *Kobresia pygmaea* (C.B.Clarke), *Kobresia felicina* (C.B.Clarke), *Potentilla fruticosa* (L.), *Arenaria bryophylla* (Fernald), *Carex spp, Spirea spp. Potentilla fruticosa* (L.) and *Kobresia spp.* are the most dominant species, which are most favored by both livestock and wild animals (Chetri & Gurung, 2004). The rangelands also provide habitat to many rare and endangered wildlife species categorized by the International Union for Conservation of Nature (IUCN). These include Snow leopard (*Uncia uncia*) (Schreber), Lynx (*Lynx lynx isabellinus*) (Blyth), Red fox (*Vulpes vulpes*) (Linnaeus), Himalayan brown bear (*Ursus arctos*) (Linnaeus), Tibetan grey wolf (*Canis lupus*) (Linnaeus), Tibetan argali (*Ovis ammon hodgsonii*) (Blyth), Tibetan gazelle (*Procapra picticaudata*) (Hodgson), Kiang (*Equus kiang*) (Moorcroft), and Himalayan Blue sheep (*Pseudois nayaur*) (Hodgson) (Figure 5.2) (Chetri & Gurung, 2004; M. Chetri & Pokharel, 2005; Paudel & Andersen, 2010).

Figure 5.2. A herd of Himalayan Blue sheep (Naur in local language) grazing in rangelands above 4000 m a.s.l. near Yara (Date: June 2018, Source: Author)

The local communities have developed and inherited a rich traditional knowledge related to the use of rangelands and their resources, and such knowledge has been significant in managing the rangelands for generations (Tulachan, 2003; Rawat et al., 2013). However, with the ongoing changes in socio-economic conditions of the local communities, the rangelands are increasingly under threat from various factors such as overgrazing and overexploitation (Dong et al., 2009). Furthermore, the changing climate patterns and their impact on the rangeland ecosystem continue to exacerbate the situation (Craig, 1996; Harris, 2010; Aryal et al., 2014).

While commonly used, field-based ground methods of monitoring rangelands are costly and time-consuming in large areas that require extensive fieldwork (Hunt Jr et al., 2003). Ground measurements are also subjected to human biases and often labor-intensive (Booth et al., 2005). Moreover, rangeland ecosystems are vulnerable to steep topography, extreme climatic conditions, and geological instability (Ning et al., 2013). As a result, inaccessibility and rough topography in

this region also become significant constraints for effective monitoring of rangelands (Farooquee, 1998; Ning et al., 2013; Bano et al., 2014).

Since the 1970s, Earth-observing satellites have developed as important tools to monitor terrestrial and aquatic ecosystem status and changes at regional and global levels. In recent years, remotely sensed data have become immensely popular in mapping natural resources and as an input data source for modeling environmental processes (Melesse et al., 2007). Remote sensing technology can be a great tool for monitoring the rangeland ecosystem. Numerous studies have implemented satellite remote sensing techniques to study the rangeland ecosystem that has proven to be efficient while facilitating comprehensive data collection by reducing the labor requirement for ground monitoring, decreasing human error by restricting the impact of human judgment, and providing an on-going image recording with greater precision (Hunt Jr et al., 2003; Booth & Tueller, 2003; Booth et al., 2005).

It has been more than four decades since Landsat-1, the first Earth resources technology satellite was launched in 1972. Satellite platforms have evolved, and sensors have experienced unprecedented development over the years from 1972. Today, we have access to many freely available satellite data from sensors such as Landsat-8, Advanced Very High-Resolution Radiometer (AVHRR), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Moderate Resolution Imaging Spectrometers (MODIS), Sentinel-2A and Sentinel-2B. Commercial Satellite includes IKONOS, OrbView, GeoEye, WorldView, RapidEye, EROS, etc.

In Nepal, there has been a significant increase in the application of satellite remote sensing in natural resources in particular for land cover mapping and change detection. A recent study conducted by Uddin et al. (2014) mapped the land cover of Nepal by using Landsat data. The study estimated 39.1% of Nepal is covered by forests, 11.3% by grasslands and shrublands, and 8.5% by

snow/glaciers. Baniya et al., (2018) studied vegetation changes using Normalized Difference Vegetation Index (NDVI) obtained from AVHRR sensors and found that the overall increase in vegetation occurred from 1982 to 2015 in Nepal. The study also investigated the impact of climate on vegetation and found that temperature was a principal climatic factor affecting vegetation. A recent study by Krakauer et al. (2017) reported an uneven increase in vegetation from 1981 to 2015 concentrated at low and middle elevations during the post-monsoon period. The study concluded that vegetation in arid and semi-arid areas (e.g. Upper Mustang region) is highly dependent on moisture availability. Zhang et al. (2013) studied vegetation trend from 1981 to 2011 in the Koshi river basin (lowlands of Nepal) using AVHRR and SPOT-4 derived vegetation data. The study reported an increase in vegetation from 1982 to 1994, a decrease from 1994 to 2000 and again an increase from 2000 to 2011 while determining that temperature and precipitation were significant factors affecting vegetation growth.

Semi-arid regions, characterized as those regions of the world where water is a significant constraint on plant growth, have become the topic of increased concern due to the impacts of existing global changes (Fensholt et al., 2012). However, limited studies have been carried out in the semi-arid region of Nepal, Upper Mustang region, using remote sensing technology. One of such few studies was done by Paudel and Anderson (2010), which looked at the rangeland degradation using Landsat and SPOT images from 1976 to 2008 using a limited number of images. They also studied the interrelationship between vegetation and precipitation variability by utilizing AVHRR images (1981 – 2006). The study reported rangeland degradation in Upper Mustang mostly due to overgrazing, with annual precipitation being the dominant factor for inter-annual variability in vegetation. Similarly, in 2011 they also studied the snow cover variability in the region using MODIS imagery (2000 - 2010) and found that there has been a decline in snow cover

in the last decade with peak snowfall period delayed by about six to seven days per year (Paudel & Andersen, 2011). While Mishra et al., (2014) also reported a decreasing trend of snow cover in winter and spring due to increasing temperature and decreasing precipitation.

The shortcomings of these limited available studies are: 1) considering short time frames to study changes, in particular, those related to vegetation studies, 2) focusing more on "available" data rather than "appropriate" and "appropriately-timed" data to study changes and 3) using a limited number of remote sensing imagery and existing data gaps. With the limited number of updated remote sensing studies in the region, there is a need to better evaluate and obtain knowledge and information about the rangeland ecosystem in the Upper Mustang region using remote sensing techniques. The availability of more advanced remote sensing sensors and access to long-term historical data archives from sensors such as MODIS that collect imagery on daily basis, there is an opportunity to overcome the above-mentioned shortcomings and provide a better understanding of changes and their driving forces. This study aims to bridge those gaps and provide useful information regarding the current condition of the rangeland ecosystem in the Upper Mustang region, as well as identify changes over the past years as influenced by climatic and anthropologic factors. Two main variables studied were changes in vegetation cover in the growing season and permanent snow/ice cover. Additionally, climatic datasets were also analyzed.

5.2 Materials and Methods

5.2.1 Remote Sensing Data

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument onboard the Earth Observing System (EOS) Terra (launched in 1999) and Aqua (launched in 2002) platforms, designed to monitor the Earth's atmosphere, ocean, and land surface. Both Terra and

Aqua MODIS instruments view the entire surface of the Earth every one to two days, acquiring data across 36 spectral bands from 0.4 µm to 14.4 µm and at varying spatial resolutions; 250 m (bands 1-2), 500 m (bands 3-7) and 1 km (bands 8-36). The data derived from MODIS sensors have a wide range of applications ranging from mapping vegetation and ocean chlorophyll fluorescence to producing cloud and aerosol, fire occurrences, snow cover on land, and sea ice in the oceans products (Justice et al., 1998; Zhang et al., 2003).

5.2.2 Spectral Indices

Remote sensing scientists have developed various spectral indices to help them predict, model, or infer surface processes on earth. These indices have been used to assess and monitor several different land change processes including vegetation (Tucker et al., 1991; Myneni et al., 1997; Zhang et al., 2003; Anyamba & Tucker, 2005; Paudel & Andersen, 2010; Uddin et al., 2015; Krakauer et al., 2017), snow cover (Salomonson & Appel, 2004; Bolch et al., 2008; Paudel & Andersen, 2011), soil moisture and drought (Wang & Qu, 2007; Kogan, 1995; Rahimzadeh-Bajgiran et al., 2008 & 2012), burned area (Maki et al., 2006), man-made (built-up areas) features (Herold et al., 2002; Zha et al., 2003; Xu, 2008), and various geological features (Clark et al., 2003; van der Meer et al., 2012).

NDVI is one of the most widely used indices to monitor vegetation status (Tucker, 1979; Tucker et al., 1981). Similarly, the Normalized Difference Snow Index (NDSI) is an index used to map snow cover. Indices such as NDVI and NDSI have become common remotely sensed indices and are produced by NASA on a daily basis for the entire globe using satellite sensors like MODIS Terra and Aqua; these make the use of remote sensing tools easier in environmental studies. In this

study, we have utilized the time-series of MODIS derived NDVI and NDSI data to monitor the vegetation and snow cover status in the Upper Mustang region.

5.2.2.1 Normalized Difference Vegetation Index (NDVI)

The NDVI is obtained by calculating the normalized reflectance difference between the near-infrared (NIR) and visible red band (Tucker, 1979). It is a widely used index as a proxy for landscape-scale vegetation amount and vigor (Tucker, 1979; Garroutte et., 2016). The NDVI is calculated as follows:

$$NDVI = (NIR - Red) / (NIR + Red) \quad (1)$$

NIR and *Red* stand for the spectral reflectance measurements in the near-infrared and red (visible) regions, respectively. The index is based on the fact that chlorophyll absorbs red light whereas the mesophyll leaf structure scatters NIR (Kremer & Running, 1993). Theoretically, the value ranges from -1 to 1, where the common range for green vegetation is from 0.1 to 0.8 while bare soil, clouds, and snow areas are characterized by the negative value of the index (Lillesand & Kiefer, 1979; Burrough & McDonnell, 1998).

Because of its sensitivity to vegetation growth status, productivity and vegetation cover types, NDVI has been the most widely used indicator to represent vegetation status among various vegetation indices (Tucker, 1979; Peng et al., 2012). Numerous studies have utilized NDVI to study vegetation changes (seasonal and inter-annual) in arid and semi-arid environments in different places of the world. Peng et al. (2012) analyzed the vegetation trend using Global Inventory Monitoring and Modeling System (GIMMS)-NDVI data and reported a significant increase in vegetation in Qinghai-Tibetan plateau during 1982-2003. By using SPOT VEGETATION NDVI, Tang et al. (2017) investigated the spatiotemporal changes of vegetation

growth in the Upper Shiyang river basin in China. The study reported increased NDVI in 81.3% of the study area with a prolonged growing season. While using relatively coarse remote sensing image (AVHRR NDVI), Weiss et al. (2004) examined 11 years (1990-2000) of seasonal and inter-annual variability in vegetation in a diverse semi-arid setting with six different vegetation communities in central New Mexico in USA, and reported high inter-annual variability among the six vegetation types during the 11-year period. Zoungrana et al., (2018) studied vegetation degradation by using MODIS NDVI during 2000-2011. The study revealed a decreasing NDVI trend due to the vast conversion of natural vegetation into agriculture and non-vegetated area. While utilizing the same data source, Rahimzadeh Bajgiran et al., 2009 conducted a study to detect drought in the semi-arid region of Iran. The study revealed the usefulness of MODIS NDVI in long term environmental monitoring and detection of changes in a semi-arid region.

For this study, we used MODIS/Terra MOD13Q1 NDVI dataset spanning the period from 2000 to 2018 (https://earthdata.nasa.gov/). The MODIS MOD13Q1 dataset is produced on a per-pixel basis and relies on multiple observations over a 16-day period to generate a composite NDVI image (Didan, 2015). The algorithm is based on the best available pixel values from all the acquisitions form the 16-day period (Figure 5.3). MODIS MOD13Q1 images used in this work are a gridded level-6 product delivered in a sinusoidal projection and have a 250-meter spatial resolution. The MODIS NDVI product is produced from atmospherically-corrected bi-directional surface reflectance and contains information about clouds, perceptible water, aerosol products

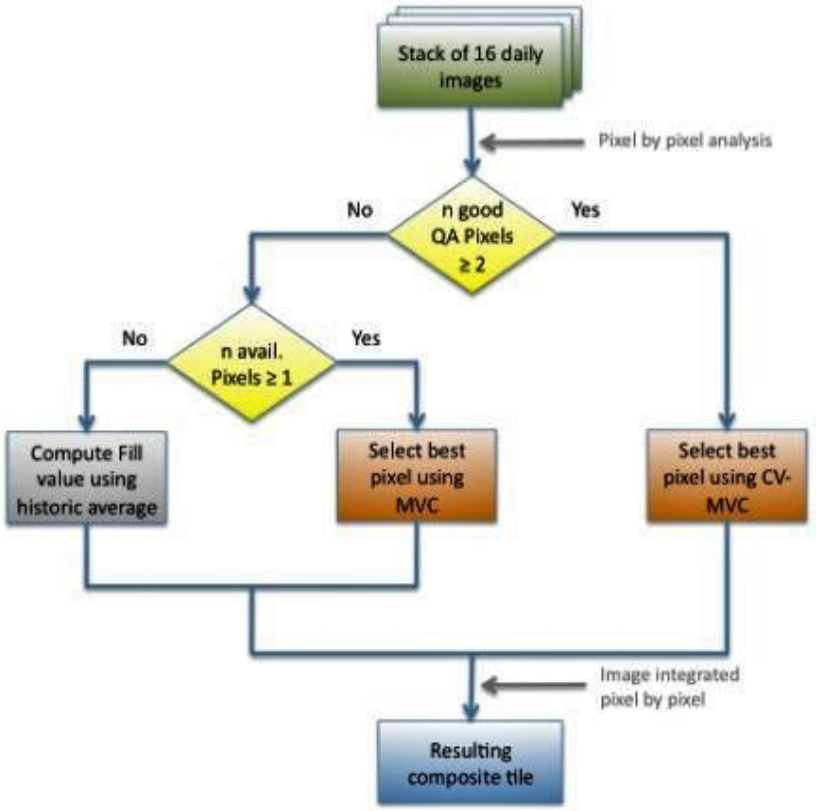


Figure 5.3. MODIS NDVI compositing algorithm flow (Source: https://lpdaac.usgs.gov/products/mod13q1v006/)

and cloud shadows with quality assurance flags associated with atmospherically corrected products (Huete et al., 2002). Images spanning the growing season (May–September i.e. DOY 113-DOY 273) were considered for this study, resulting in 209 images in total (11 images each year).

5.2.2.2 Normalized Difference Snow Index (NDSI)

The NDSI is a measure of the relative magnitude of the reflectance difference between green and shortwave infrared (SWIR) bands (Hall et al., 2002). It is an index that represents the presence of snow on a pixel basis. The equation for the NDSI is as follows,

$$NDSI = (Green - SWIR)/(Green - SWIR) \quad (2)$$

where *Green* and *SWIR* stand for the spectral reflectance measurements in the green (visible) and short-wave infrared regions, respectively. A pixel with NDSI > 0 is considered to have some snow present whereas a pixel with NDIS <=0 is snow-free land surface (Riggs & Hall, 2016).

We used MODIS/Terra MOD10A2 snow product for this study from 2000 to 2018. The product has a spatial resolution of 500m and provides the maximum extent of snow cover over an eight-day period. The maximum snow extent is where snow was observed on at least one day during the eight-day period (Riggs & Hall, 2016). MOD10A2 data sets are generated by compositing the daily snow cover product – MOD10A1. For the MOD10A2 8-day snow-cover product, the algorithm aims to maximize the number of snow pixels while minimizing the number of cloud pixels (Zhou et al., 2005; Riggs & Hall, 2016). MOD10A2 products were downloaded from Earth Observing System Data and Information System (EOSDIS) (https://search.earthdata.nasa.gov).

Numerous researchers have utilized MOD10A2 data sets and reported accuracy in the range of 88% to 93% (Hall et al., 2002; Maurer et al., 2003; Paudel & Andersen, 2011; Riggs & Hall, 2016). However, according to a study conducted by (Wang et al., 2008) in northern China, MOD10A2 had low accuracy for patchy or thin snow with snow depth less than 4 cm misclassified as land.

Jain et al., (2008) reported better MODIS snow product results in comparison with National Oceanic and Atmospheric Administration (NOAA) and Indian Remote Sensing Satellites (IRS) data. In addition, the study tested the accuracy of snow mapping in relation to elevation and found that MODIS showed better snow mapping capacity under mountain shadow conditions. Similarly, Shrestha et al., (2011) conducted a study in the Dudhkoshi region in the eastern region of Nepal.

Snow mapping using MOD10A2 products showed approximately 90% precision. This demonstrates that MOD10A2 can be very useful for monitoring snow cover in Upper Mustang's mountain terrain where ground observation is completely non-existent.

In this study, to measure the permanent snow/ice cover, we only considered June to August (DOY 145 to DOY 241) time period, resulting in 247 images in total (13 images each year). We considered this time period to avoid the temporary snow cover in the study area. Generally, the period of October to April is characterized as the winter season where precipitation occurs in the form of snowfall, while some early or late snowfall has also been observed before these periods in this region.

5.2.3 Climatic Datasets

We obtained daily rainfall and temperature data during 1972 – 2016 from the Department of Hydrology and Meteorology (DHM) in Kathmandu, Nepal. There are 10 available meteorological stations (entire Mustang district) out of which five are located in the Upper Mustang region (Figure 5.4). The details of meteorological data are listed in the table 5.1.

Table 5.1. Meteorological stations and data availability in the study area

Station number	Station Name	Climate variables	Period	Latitude (°N)	Longitude (°E)	Altitude (m a.s.l.)
72	Jomsom	Temperature, Rainfall	1957-2016, 1957-2016	28.47	83.43	2744
73	Marpha	Temperature, Rainfall	1969-2016, 1967-2016	28.45	83.42	2566
76	Lete	Temperature, Rainfall	1998-2016, 1969-2016	28.38	8336	2384
77	Ranipauwa (Muktinath)	Rainfall	1969-2016	28.49	83.53	3609
79	Ghami	Rainfall	1973-2012	29.03	83.53	3465
80	Lomanthang	Temperature, Rainfall	1973-2005, 1973-2005	29.11	83.58	3705
89	Dhee	Rainfall	1992-2014	29.06	84.00	3620
90	Samar	Rainfall	1992-2016	28.58	83.47	3570
91	Sanda	Rainfall	1992-2016	28.54	83.41	3570
97	Chhoser	Temperature, Rainfall	2005-2016, 2005-2016	29.11	83.59	3870

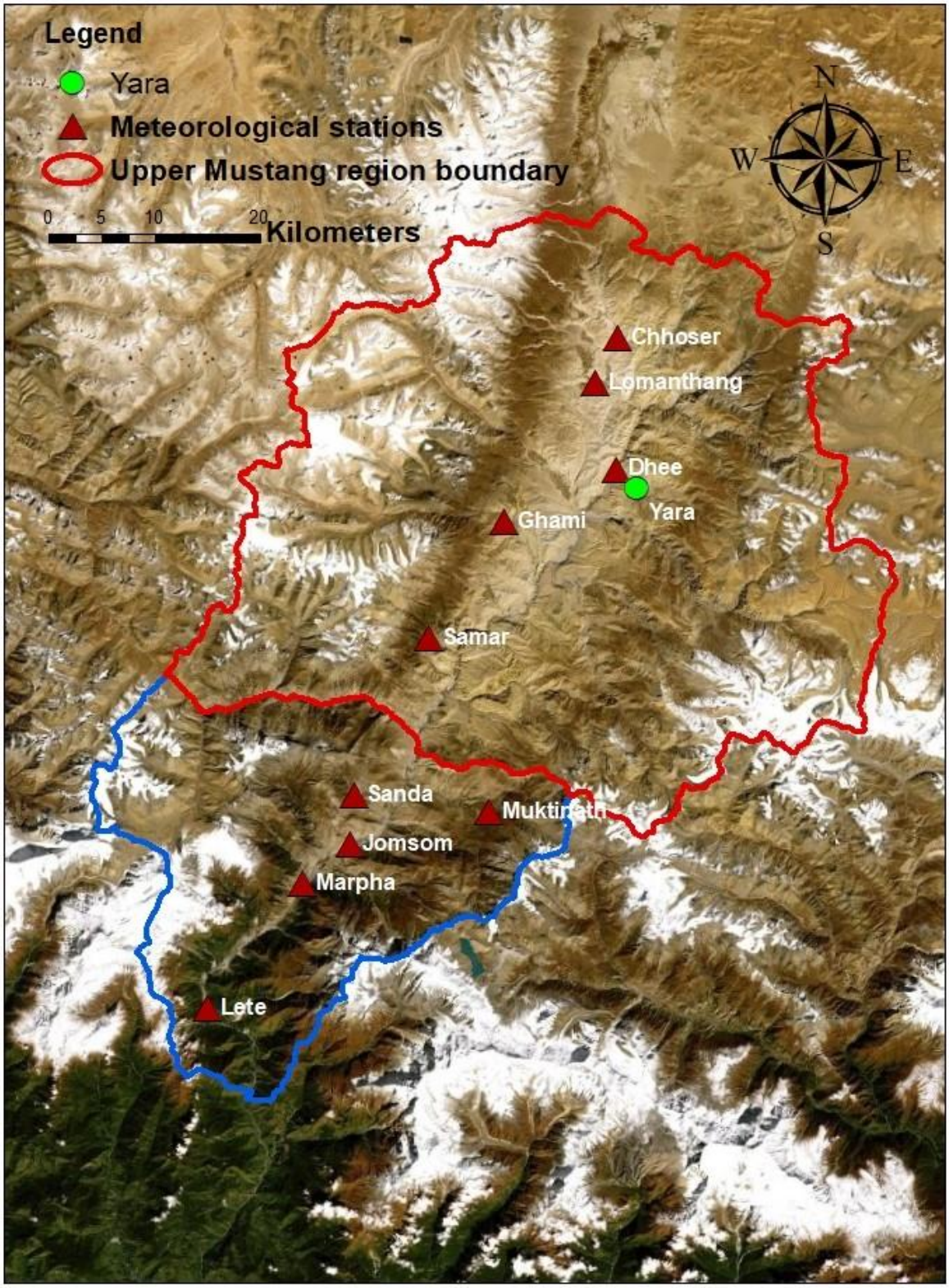


Figure 5.4. The study area (Upper Mustang region in red boundary) with the location of available meteorological stations and Yara village.

5.3 MODIS NDVI and NDSI Images Pre-processing

MODIS products are originally in HDF format and have sinusoidal projection. While downloading the data from website "https://search.earthdata.nasa.gov", imageries were converted to Geotiff format with UTM projection. We acquired the h25v06 tile which covers the entire study area for the time period 2000 to 2018. Subset images were extracted from the tiles using the administrative boundary of the study area in ENVI image analysis software. Image processing, mapping, and spatial analyses were conducted in ENVI integrated with ArcGIS software.

For NDVI imagery both maximum and mean annual NDVI values were estimated for the period 2000 to 2018 during the growing season (DOY 123-DOY 273). Maximum NDVI was calculated by taking the maximum value from 13 images for each year. While mean NDVI was calculated by first taking the maximum value for each month (June-August) and then calculating the average of those months for each year from 2000 to 2018.

To obtain the measure of permanent snow/ice cover, pixels representing snow (Table 5.2) were extracted and the snow cover area was calculated for June to August (DOY 145 to DOY 241) period from 2000 to 2018.

Table 5.2. Pixel cover types of the MOD10A2 product

Pixel value	Pixel cover types
0	Missing data
1	No decision
11	Night
25	Land without snow cover
37	Lake
39	Ocean
50	Cloud
100	Lake ice
200	Snow
254	Detector saturated
255	Fill

5.4 Climate Datasets Pre-processing for Statistical Analysis

Temperature data were available from two stations in Upper Mustang: Chhoser and Lomanthang stations. However, the available data were limited at each station. The Lomanthang station only covered the period 1973-2005, whereas the Chhoser station only had data from 2005 to 2016 available. As these two stations were close to each other (~ 5 km) (Figure 5.4), available data from these stations have been merged and analyzed as a single station.

We also obtained temperature data from the Jomsom station in the Lower Mustang region. This station was the longest-running station and provided ongoing data up to 2016. Statistical analyses were done for both stations (Jomsom and Lomanthang/Chhoser combined), which is presented in the results section 5.8.1.

Rainfall data were available from five stations in Upper Mustang: Lomanthang (1973-2005), Chhoser (2005-2016), Dhee (1992-2014), Ghami (1973-2012), and Samar (1992-2016). Similar to the temperature analysis, we merged data from Lomanthang and Chhoser stations to make a single station for rainfall analysis. Data from the other two stations: Dhee and Ghami were also analyzed. These two stations were the closest stations from the case study village, Yara. Additionally, we also analyzed the rainfall trend for Jomsom station for a time spanning 1986 to 2016. The results of the statistical analyses are presented in section 5.8.2.

5.5 Statistical Tests for Trend Analysis

Statistical trend analyses were used for both remote sensing and meteorological data to detect changes and to evaluate positive or negative trends over the years covered in this study. The trend tests applied in this study were either the non- parametric Mann-Kendall test (Mann, 1945;

Kendall, 1975) and the simple linear regression method depending on their fitness for the target data and analysis.

5.5.1 Simple Linear Regression

Simple linear regression was applied to analyze and quantify the trend of climate variables (rainfall, temperature) and permanent snow cover/ice area. This is one of the most common tests for trend analysis and, in its basic form, assumes that data are normally distributed (Kundzewicz & Robson, 2004). This technique was developed by Sir Francis Galton (1894) and is capable of deriving the quantitative trend together with the serial correlation in the time series (Stanton, 2001). Linear regression is the most common method for detecting climate change trends and has been used widely in previous studies (Wang et al., 2001; Zhao et al., 2011; Yuan et al., 2019). The equation is as follows,

$$y = ax + b, \quad (3)$$

In equation (3), y (rainfall or temperature or snow cover area) is the dependent variable, x (time) is the independent variable, and a, b are the slope of the trend line and intercept, respectively.

5.5.2 Mann-Kendall Trend Analysis

We used the Mann-Kendall test to study the monotonic trend in time series of NDVI at the pixel level while Theil-Sen's method was used to compute the magnitude of the trend. R programming software was used for the analysis. Mann-Kendall is a non-parametric rank-based procedure that compares the relative magnitudes of sample data (Mann, 1945; Kendall, 1975). In recent years, scholars have been increasingly utilizing this method in studying various remote sensing indices trends (de Jong et al., 2011; Neeti & Eastman, 2011; Fensholt & Proud, 2012;

Jiang et al., 2015). Mann-Kendall test has been considered a robust method in case of spatial analysis and representation. The major advantage of Mann-Kendall statistic is that it is less affected by outliers (Birsan et al., 2005) compared to the linear least square method. Mann-Kendall test examines the slopes between all pair-wise combinations of samples. In the Mann-Kendall test, the data are ranked with time, and each data point in successive periods is treated as a reference point for the data points (Hirsch & Slack, 1984).

Firstly, the Mann-Kendall method calculates S statistics, which indicates the sum of the difference between the data points shown in Eq. 4. For a time series, $X = \{x_1, x_2, \ldots . x_n\}$, the Mann–Kendall test statistic is calculated as:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \tag{4}$$

where *n* is the length of the time series data set and x_i and x_j are the observations at times i and j, respectively. The sign of the value, $sgn(x_j - x_i)$ is defined as follows:

$$sgn(x_j - x_i) = \begin{cases} 1 \; if \; x_j - x_i > 0 \\ 0 \; if \; x_j - x_i = 0 \\ -1 \; if \; x_j - x_i < 0 \end{cases} \tag{5}$$

The sign of the value of S indicates the direction of the trend. The S statistic is approximately normal when $n \geq 8$ (Mann, 1945; Kendall, 1975). When there is no tie between data values then the mean and variance are given by:

$$E(S) = 0 \tag{6}$$

$$Var(S) = \frac{n(n-1)(2n+5)}{18} = \sigma^2 \tag{7}$$

where σ is the standard deviation.

When there are ties between the data values, the variance is calculated as:

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18} \tag{8}$$

where *n* is the number of data points, *m* is the number of tied groups and t_i denotes the number of ties of extent *i.* A tied group is a set of sample data with the same value. The statistical significance of S is checked using a test statistic (or Z_s). The standardized Mann-Kendall statistics Z_s follows the standard normal distribution with zero mean and unit variance as shown in equation 9:

$$Z_{s=}\begin{cases} \frac{S-1}{\sqrt{Var(S)}}, if\ S > 0 \\ 0, \qquad if\ S = 0 \\ \frac{S+1}{\sqrt{Var(S),}} if\ S < 0 \end{cases} \tag{9}$$

The Mann-Kendall method tests the null hypothesis (H0), which indicates no distinct trend against the alternative hypothesis (H1) indicating a trend. Two-tailed tests are used to determine

whether or not to reject the null hypothesis in favor of the test of the hypothesis. The null hypothesis, H0 is tested by the statistical value of the Z test. A positive Z_s value indicates an upward or increasing trend, while a negative value indicates a downward or decreasing trend.

The trend's significance is assessed by comparing the Z value with the standard normal variance at the pre-specified level of statistical significance. The null hypothesis is rejected, and a significant time series trend exists when $|Z_s| > Z_{1-\alpha/2}$. $Z_{1-\alpha/2}$ is obtained from the standard normal distribution table. In this study, the significance level of $\alpha = 0.05$ was used (Yue & Wang, 2002; de Jong et al., 2011; Neeti & Eastman, 2011).

5.5.3 Theil-Sen's Slope Estimator

The magnitude of the trend identified by the Mann-Kendall test over time was estimated using Theil-Sen's approach (Theil, 1950; Sen, 1968). The Theil-Sen's slope estimator is a robust nonparametric trend operator and is highly immune to a gross data error. It is calculated by determining the possible slopes between all possible data pairs and then finding the median value as shown in equation 10.

$$Q_{i=} \frac{X_j - X_k}{(j-k)}, \text{ for all } j > k \quad (10)$$

where Q_i is the slope between data points, i = 1,2,3…N and X_j is data measurement at time j, X_k is data measurement at time k. For n values of the time series of x results, N = n (n-1)/2 values of Q_i. The median of these N values of Q_i is the slope of Theil-Sen's estimator, which is calculated as:

$$Q_i = Q_{[(N+1)]/2]}, \text{ if N is odd} \quad (11)$$

$$Q_i = 1/2(Q_{[(N+1)]/2]} + Q_{[(N+2)]/2]}), \text{ if N is even} \quad (12)$$

5.6 Correlation between Rainfall and NDVI

The Pearson correlation coefficient between NDVI and rainfall was calculated to assess the impact of rainfall on vegetation dynamics. As suggested by Evans and Geerken (2004), we computed the correlation between various combinations of rainfall accumulation and growing season maximum NDVI (June – August). Maximum NDVI values were extracted from 3*3 pixel window sample sites from different locations representing the rangeland nearby the respective meteorological stations. Various windows of rainfall accumulation were tested ranging from August to twelve preceding months (Table 5.3). Accumulated rainfall of January to August was found to be the best predictor of the growing season (June–August) maximum NDVI. Table 5.3 shows the correlation coefficients (r) between max NDVI and accumulated rainfall.

Table 5.3. Pearson correlation coefficient (r) between max NDVI and different rainfall patterns

Accumulated rainfall (mm)	Pearson correlation (r), June-August max NDVI	Significance	Pearson correlation (r), August NDVI	Significance
August	-	-	0.20	0.44
July-August	-	-	0.41	0.10
June-August	0.42	0.10	0.43	0.09
May-August	0.40	0.11	0.42	0.09
April-August	0.41	0.10	0.42	0.09
March-August	0.37	0.14	0.38	0.13
February-August	0.49 *	0.05	0.49 *	0.04
January-August	0.54 *	0.02	0.53 *	0.03
December-August	0.52 *	0.03	0.50 *	0.04
November-August	0.53 *	0.03	0.51 *	0.04
October-August	0.47	0.06	0.46	0.07
September-August	0.52 *	0.03	0.50 *	0.04

*** Statistically significant at 95% confidence level**

January to August accumulated rainfall was interpolated for all available meteorological stations using the Inverse Distance Weighted (IDW) method (Shepard, 1968; Hartkamp, Beurs, Stein, & White, 1999; Li & Heap, 2008). Pixel-wise Pearson correlation was calculated between growing season's maximum NDVI and accumulated rainfall from January to August to spatially map correlations between NDVI and rainfall in the study area.

5.7 NDVI Residual Trend Analysis

NDVI residual trend analysis is an approach that separates the changes in NDVI caused by other factors (e.g., anthropogenic effects) from those resulting from climatic variations (Evans & Geerken, 2004). As suggested by Evans and Geerken (2004), NDVI residuals were calculated for each pixel, which is the difference between the observed maximum NDVI and the predicted maximum NDVI. The NDVI residual trend was also analyzed to detect the trend over time. Any trend through time present in the residuals then indicated the changes in maximum NDVI that is not due to climatic variations. Thus, a significant negative trend in time series NDVI residuals indicates degradation of rangeland due to anthropogenic impacts (Evans & Geerken, 2004).

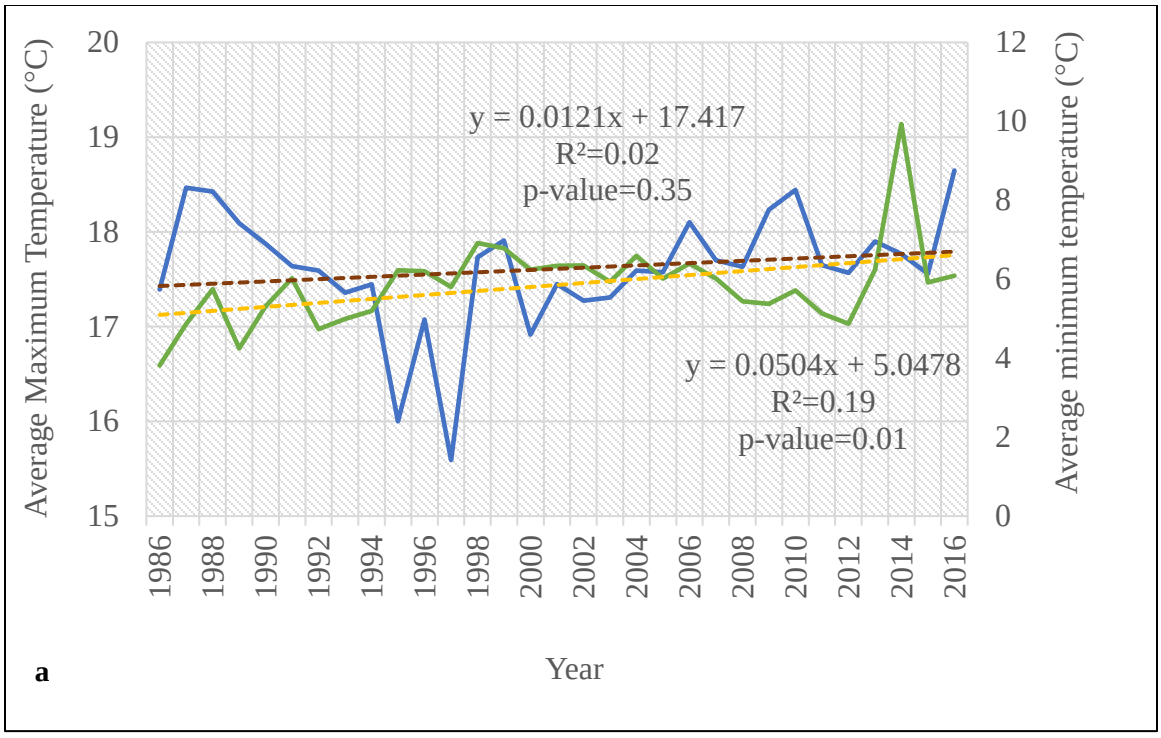
5.8 Results and Discussion

5.8.1 Temperature Trend

Figures 5.5a and b show the temperature trend at Jomsom (located in Lower Mustang region at 2744 m a.s.l,), and Lomanthang and Chhoser stations located in Upper Mustang region (closest station from our case study village, at 3705 & 3870 m a.s.l.). An increasing temperature trend was seen in both stations. The average annual maximum and minimum temperatures were found to be increasing at the rate of 0.012°C and 0.05°C annually in Jomsom station, respectively

(Figure 5.5a). The average annual maximum temperature did not show any significant trend (p-value=0.35) with R^2=0.02. However, the average annual minimum temperature trend showed a significant decrease (p-value=0.01) over a period of 30 years with R^2=0.19.

Similarly, the average annual maximum and minimum temperature at Lomanthang/Chhoser station showed an increasing trend spanning the years 1973 to 2016 (Figure 5.5b). The average annual maximum temperature increased at a rate of 0.085°C annually. Likewise, the average annual minimum temperature showed an increasing trend at the rate of 0.0743°C annually. Both average annual maximum and minimum temperature trends were significant (p-value<0.001, R^2=0.37 & p-value<0.001, R^2=0.34) at 95% confidence level.



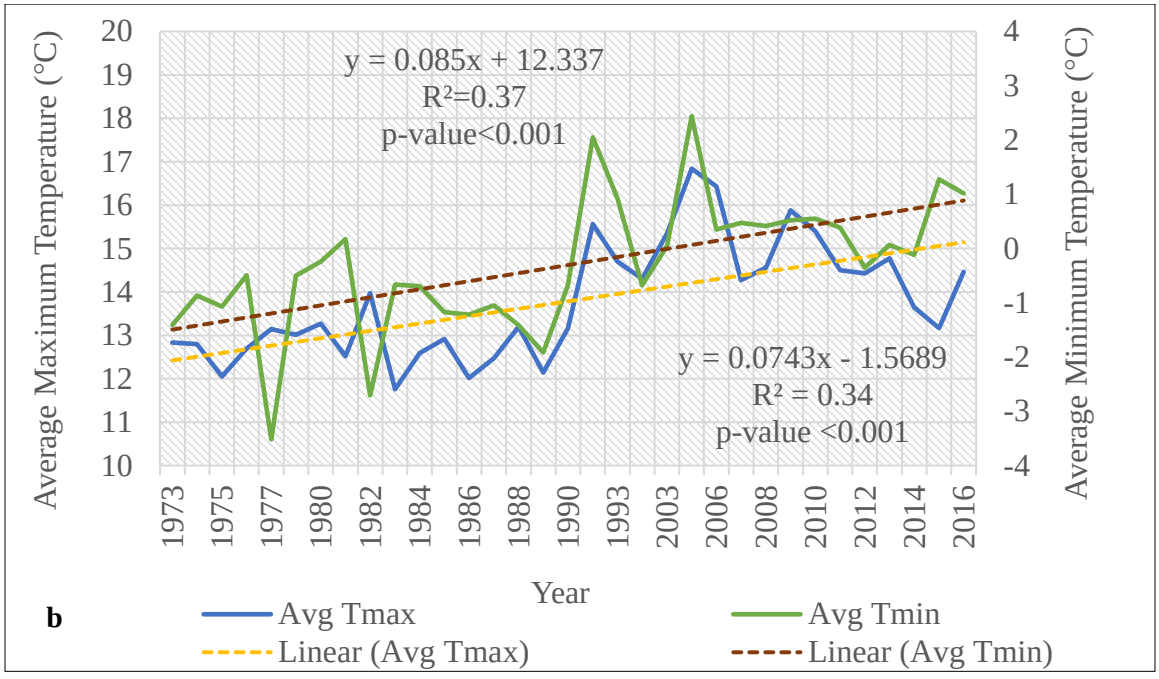


Figure 5.5. Average annual maximum and minimum temperature trends at a) Jomsom (1986-2016) b) Lomanthang (1973-2005) and Chhoser (2006-2016) combined

These findings were also in line with local people's view and knowledge. When asked about the temperature change during household interviews, most local people mentioned the rising temperature trend over the past few years. Some local people also stated that winters are not as chilly as before. “In recent years the winters have been relatively warm. In the past, it had been severe cold, and winters began in late August. But winter isn't cold now and snowfall has decreased as well,” said an elderly female respondent from Yara during the household interview. This could be explained by the increasing pattern in average annual minimum temperature as observed through temperature data analysis.

This increasing trend is also in accordance with previous studies conducted in Nepal which showed an increase in temperature in the mountainous region of Nepal compared to the low lands of Terai region (Shrestha et al., 1999; Eriksson et al., 2007; Shrestha et al.,2012). Mishra et al., (2014) studied temperature trend in Kaligandaki basin based on remote sensing techniques while using MODIS/Terra land surface temperature dataset (MOD11C3). The study also reported a greater warming trend at higher altitudes. However, the study found a higher increasing rate in maximum temperature compared to the minimum temperature. Another study conducted by the International Centre for Integrated Mountain Development (ICIMOD) in the eastern Himalayan region showed that high altitude areas are relatively more exposed to warming effects than lowland and adjoining plains (Tsering et al., 2010). Eastern Himalayan region was reported to be experiencing widespread warming with generally higher than 0.01°C increase in temperature per year. With elevation, there is progressively more warming, with highest warming rates in areas > 4000 m a.s.l. (Tsering et al., 2010).

Similarly, a study conducted by Xie et al., (2010) reported a significant increase in minimum temperature as compared with the increase in maximum temperature over the 35-year

span in Tibetan Plateau. Adjacent to Tibetan Plateau, a similar kind of trend was observed in our study region where average annual minimum temperature significantly increased at both stations (Jomsom and Lomanthang/Chhoser). In general, the orientation of the valleys, patterns of cold airflow, wind velocity, humidity, cloudiness, and slopes have been characterized as the influencing factors in the minimum temperature (Gouvas et al., 2011; Kattel & Yao, 2013). The Upper Mustang region represents these characteristics in many ways and is a semi-arid region of Nepal.

5.8.2 Rainfall Trend

Rainfall trends differed depending on the location of the station. The average annual rainfall was in increasing order at Jomsom and Lomanthang/Chhoser stations (Figures 5.6a & b, respectively). The increasing trend was significant at 95% confidence level at both stations. The slopes suggested that rainfall was increasing at the rate of 3.86 mm (p-value=0.007, R^2=0.22) and 5.87 mm (p-value=0.001, R^2=0.32) annually, respectively. However, the rainfall trend showed a decreasing order at Ghami and Dhee stations (closest stations from case study village) at the rate of 1.48 and 8.50 mm annually, respectively (Figures 5.6c & d). The decreasing trend was insignificant (p-value=0.35, R^2=0.03) at Ghami station, whereas the rainfall trend at Dhee station showed a significant decrease (p=0.01, R^2=0.33).

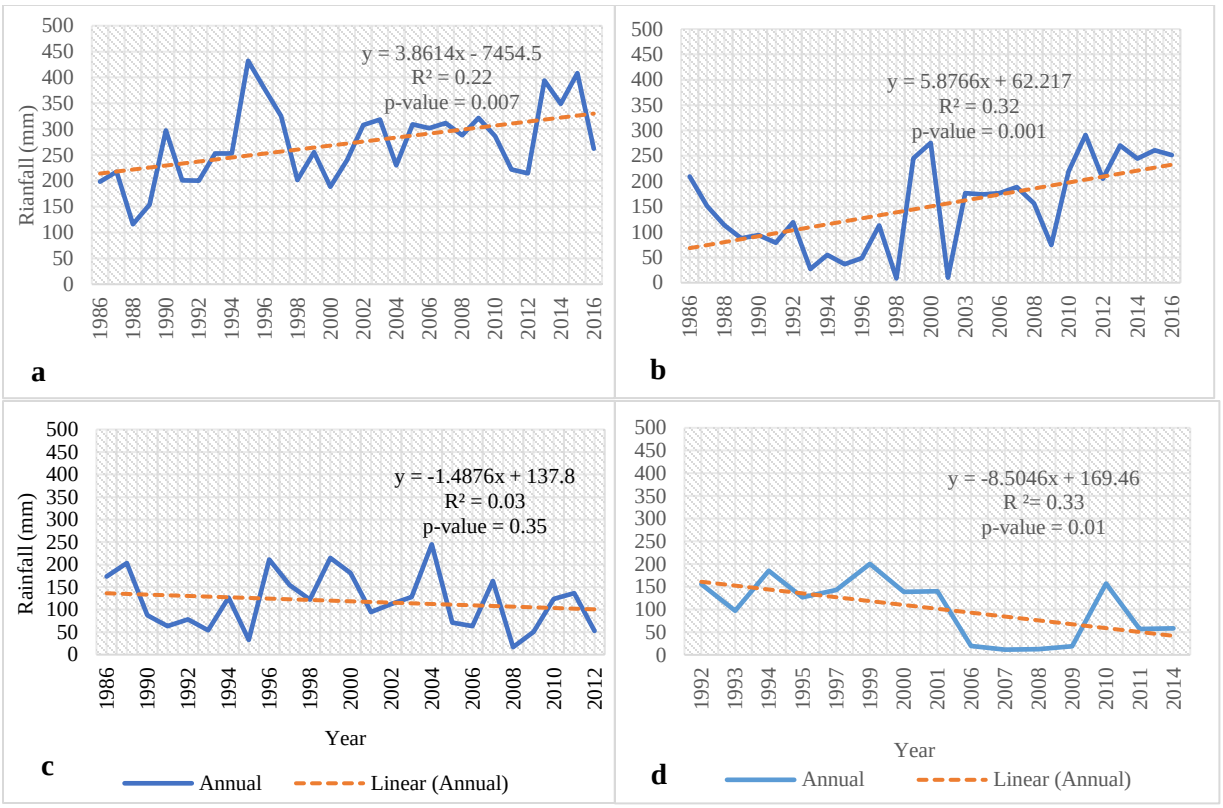


Figure 5.6. Average annual rainfall trends at a) Jomsom (1986-2016) b) Lomanthang/Chhoser (1986-2016), c) Ghami (1986-2012), and Dhee (1992 – 2014)

The rainfall pattern showed a high degree of fluctuation over the years. At Jomsom station, located in the Lower Mustang region, maximum rainfall was recorded in 1995. The minimum rainfall was observed in 2012 with a steady rise in rainfall until 2015 and a sudden decline in 2016. The amount of rainfall increased abruptly at Lomanthang station in 1999 and remained higher up to 2000 and declined after that coming to 2002. The higher fluctuation was observed at Ghami station with the highest rainfall recorded in 2004 and the lowest in 2008. Relatively high annual decline in precipitation (8.50 mm/yr.) was observed at the Dhee station, which is the closest meteorological station (2.6 km distance) from our case study village, Yara. While situated in a similar geographic region and relatively in a short distance, we observed variations in rainfall pattern at various stations. It is suggested that the variation in altitude, local climatic conditions,

and diurnal wind phenomenon might have influenced the uneven distribution of rainfall (Barros & Lang, 2003; Bhutiyani et al., 2007; Ichiyanagi et al., 2007; Malik et al., 2012).

During household interviews, local people mentioned reduced rainfall with erratic rainfall patterns (higher intensity of rains but a smaller number of rainy days and unusual rain). “Some years we get less rainfall, some years, we get strong rainfall for a short time. Both do not do any good for us. If the rainfall is low, our crops and rangelands are affected, while high rainfall causes flash floods and landslides that destroy our houses and the canals,” said an elderly female respondent from Yara village. Although Upper Mustang was already the region that had the smallest number of rainfalls in Nepal, the local populations have felt that in recent years the rainfall has declined further. In addition, local people have observed changes in the timing of rainfall. “Rainfall usually occurs between early June and July. But we have seen a change in the timing of rainfall in the recent two-three years. Rainfall is now only beginning at the end of July and lasting until August,” said a male respondent from Yara village during the household interview.

Figure 5.7 shows five years averaged monthly accumulated rainfall trend from May to September. From 1991 to 2001, maximum rainfall occurred in August in Jomsom (Figure 5.7a). However, July is recorded as the maximum rainfall month for last two decades. Similarly, during1986-1990, July was the highest rainfall month. In Lomanthang/Chhoser (Figure 5.7b), highest rainfall was recorded in July during 1986-2012. However, it has shifted towards August during 2013-2016. Ghami station (Figure 5.7c) shows rather fluctuating trend over the last three decades. July was recorded as highest rainfall month for periods; 1986-1990 and 2006-2012. Whereas, highest rainfall was recorded in August during 1991-1995, 1996-2000, and 2001-2005. Dhee station (Figure 5.7d) recorded the highest rainfall in July during 1992-1997. However, from 2000 to 2011, the highest rainfall month shifted towards August.

The shifting pattern of rainfall can be seen in Mustang region as a whole. Moreover, in the Upper Mustang region, the local perception is in accordance with the observed trend.

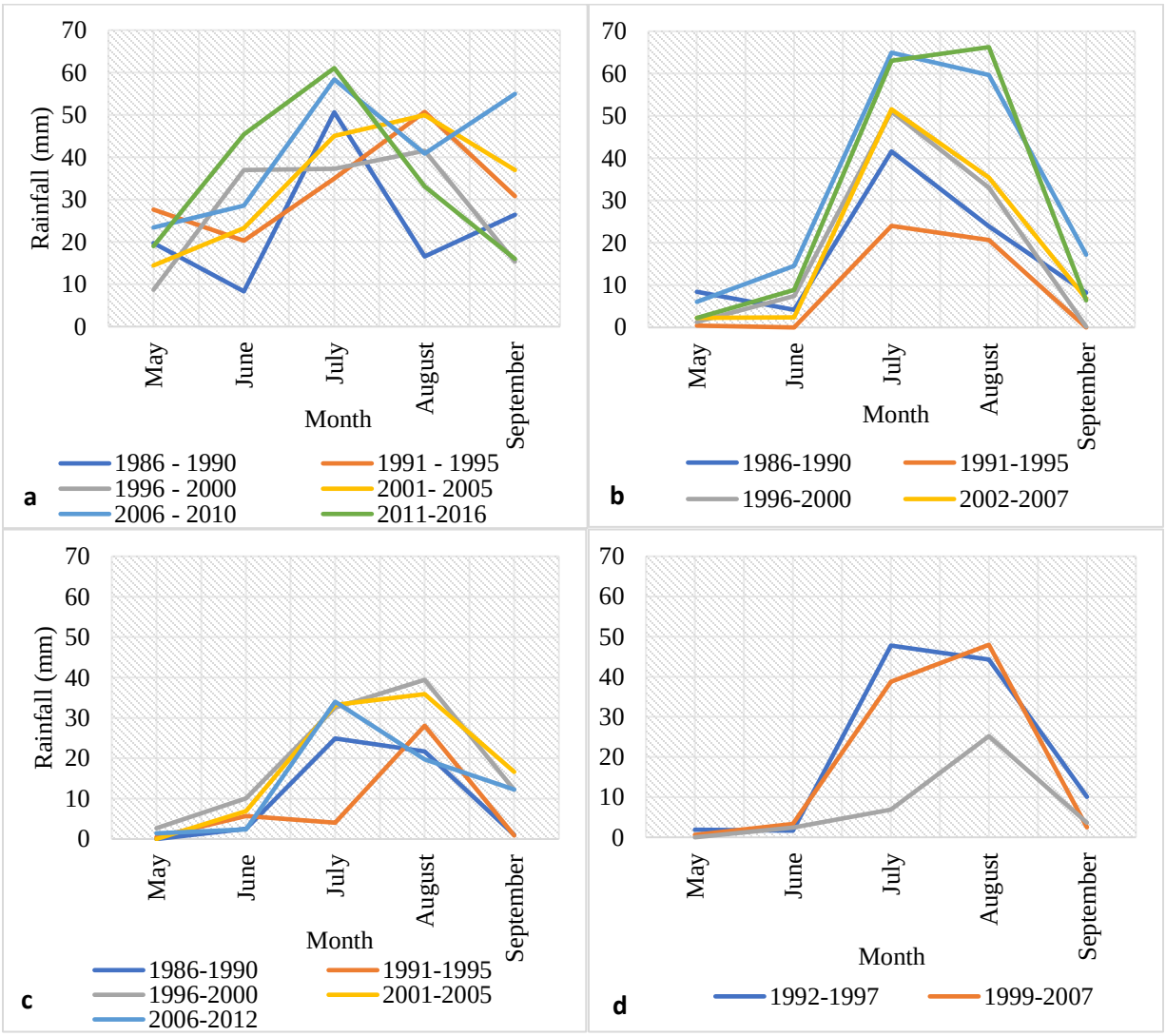


Figure 5.7. Five years average accumulated monthly rainfall pattern at (a) Jomsom (b) Lomanthang/Chhoser, (c) Ghami, and (d) Dhee

Figure 5.8 illustrates the trend of number of rainy days from May to September. Jomsom station (Figure 5.8a) showed a regular increase in rainy days whereas the other three stations (Figure 5.8b, c, and d) located in Upper Mustang showed rather fluctuating trend of rainy days.

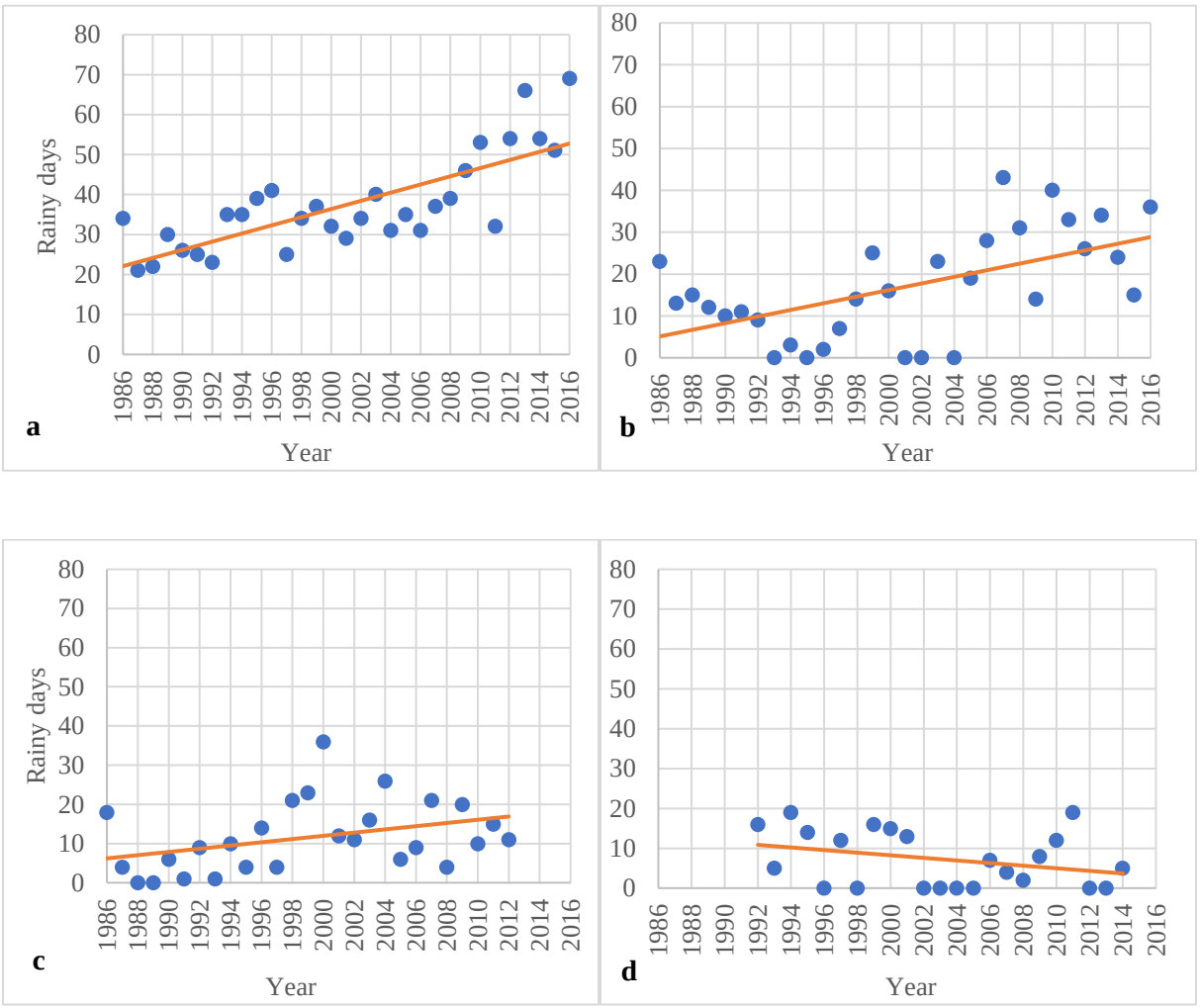


Figure 5.8. Number of rainfall days during May-September period at (a) Jomsom, (b) Lomanthang/Chhoser (c) Ghami, and (d) Dhee

Various studies in different parts of Nepal reported the erratic pattern of rainfall. Gentle & Maraseni (2012) observed erratic rainfall and the unpredictable onset of monsoon seasons in Jumla district, a remote mountainous region of Nepal. Similarly, Malla (2008) recorded growing trends in rainfall intensity causing flash floods and sediment deposition events. Erratic rainfall was

reported both in magnitude and in timing in the Budhi Gandaki River Basin in Nepal (Devkota et al., 2017). The study reported variation in the magnitude of the peaks, onset and offset of monsoon and the number of rainy days in each year from 2000 to 2009. Similar trend has been observed in other parts of the world such as in Africa (Simelton et al., 2013; Sissoko et al., 2011), Australia (Verdon et al ., 2004), northwest and southeast India, south Pakistan and in parts of the Tibetan Plateau (Malik et al., 2012). Extreme rainfalls in these areas are often linked to localized convective precipitation features.

5.8.3 MODIS Growing Season Maximum NDVI Trend

Figure 5.9a shows the average maximum NDVI (2000-2018) distribution throughout the Upper Mustang region. The average maximum NDVI is generally high in the rangeland areas of the Upper Mustang region. Small patches at a lower elevation with high NDVI represent farmland, whereas the regions with negative NDVI are non-vegetated regions mainly bare soils, water, and snow/ice cover as shown in Figure 5.9b.

Using the Mann-Kendall test, we studied the monotonic trend of growing season NDVI of each pixel against time (NDVI/Year). We employed Theil-Sen's method to compute the magnitude of the trend. Both the maximum and mean NDVI trends were calculated and tested for significance. However, the trends were not statistically significant in mean NDVI whereas the trend in maximum NDVI (NDVImax hereafter) was more statistically significant. Therefore, only NDVImax trends are presented in results.

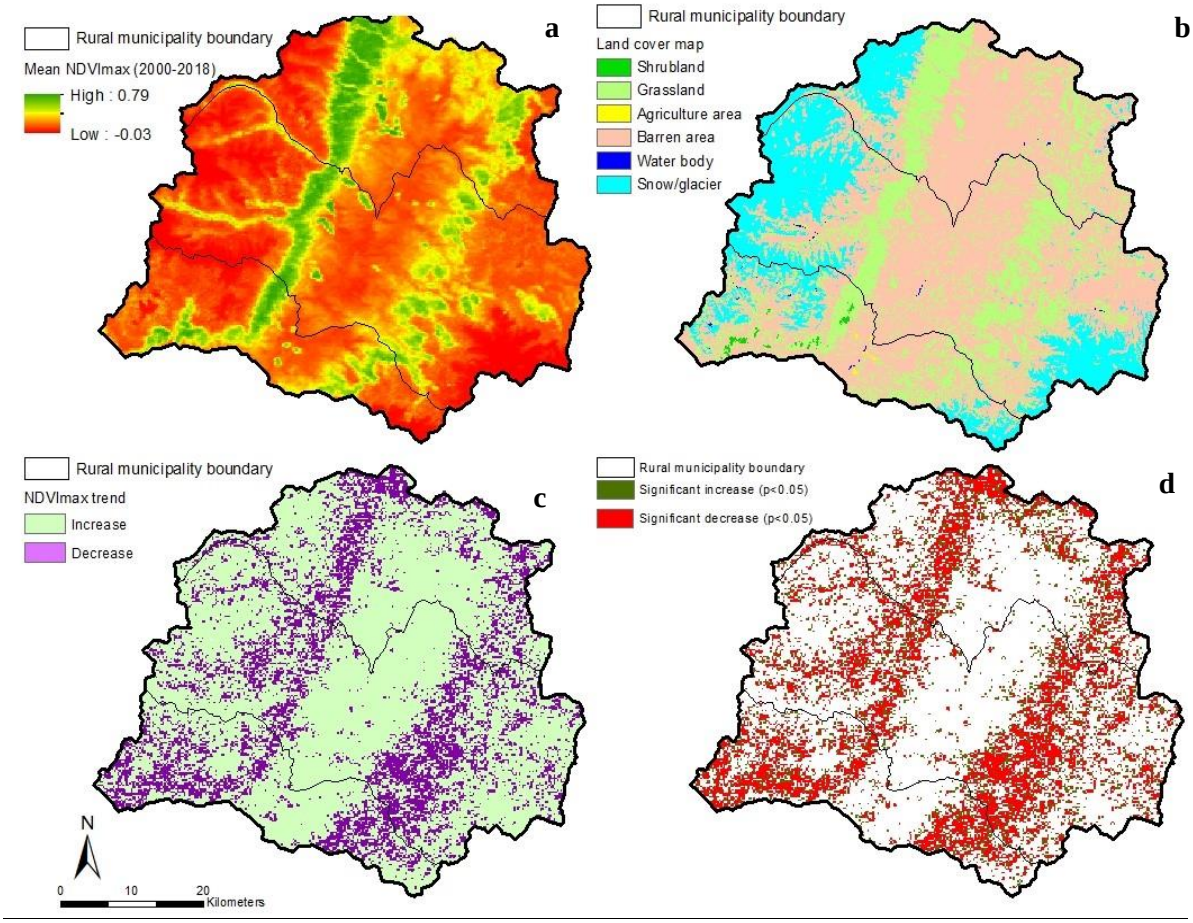


Figure 5.9. (a) Mean NDVI maximum (2000 -2018), (b) land cover map of Upper Mustang region, (c) MODIS growing season maximum NDVI trend (2000 – 2018) and (d) significance at 95% confidence level

Figure 5.9c shows the NDVImax trend against time and Figure 5.9d shows the significance at 95% confidence level. The green color indicates NDVImax increase, while the violet indicates the decrease. NDVImax (Figure 5.9c) showed an increasing trend primarily in bare soil and non-vegetated fields while a declining trend in pixels had a strong overlap with vegetation cover as shown in Figure 5.8b. The decreasing trend of NDVImax was distributed almost everywhere over rangelands in the entire Upper Mustang region.

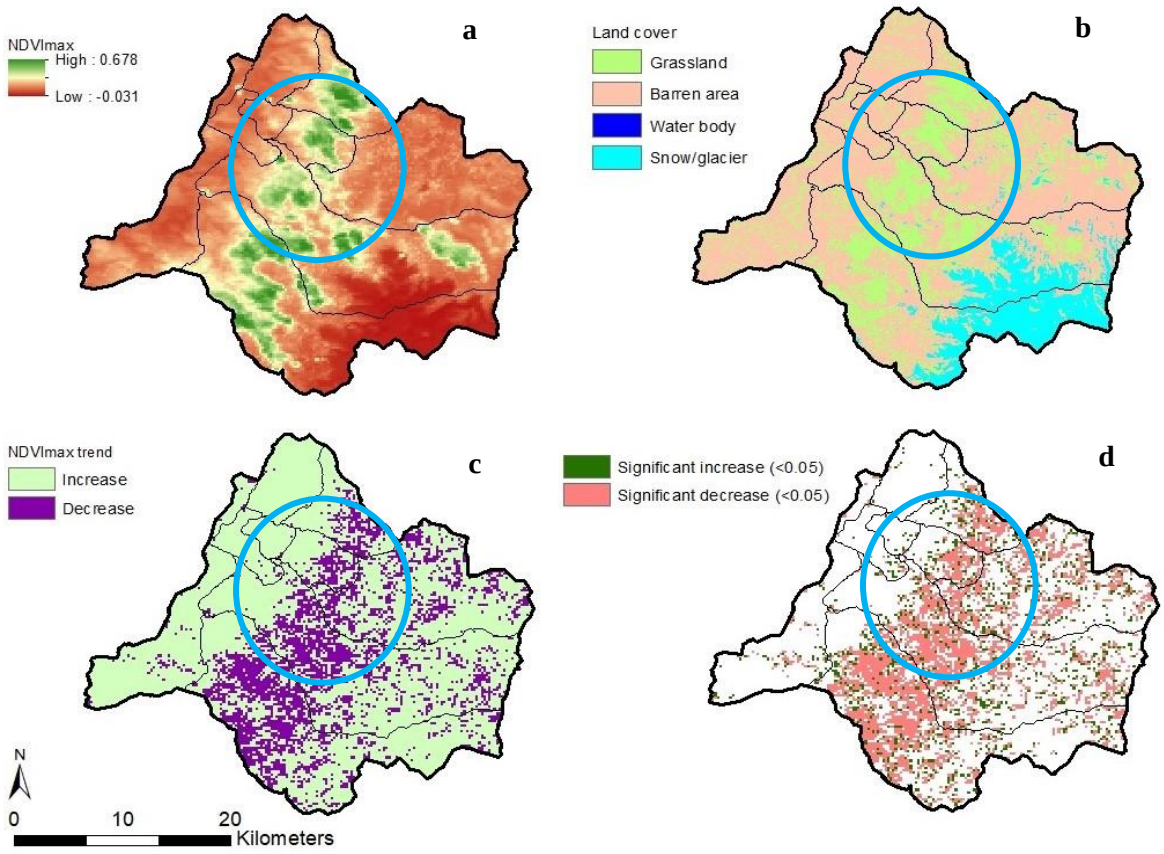


Figure 5.10. (a) Mean NDVImax (2000 -2018) (b) land cover map, c) NDVImax trend in Yara (2000-2018), and d) significance at 95% confidence level (blue circle represents rangelands of Yara village)

Figure 5.10a shows the distribution of NDVImax in Yara village. The vegetated area is distributed diagonally from north to south. Snow and glacier cover the southeast part with low NDVImax values as shown in Figures 5.10a and 5.10b, whereas less vegetated areas are observed in the eastern part. The areas with negative NDVImax values on the western side are mainly low elevation zones mostly comprised of barren lands while the small green patches represent settlement areas.

The annual trend of NDVImax is shown in Figure 5.10c. The decrease in NDVImax appeared in most parts of the rangelands. Furthermore, the significance test at 95% confidence level confirmed that NDVImax significantly declined over the years in rangelands (Figure 5.10d).

In the last 19 years, a significant trend in the NDVImax decline demonstrated the degradation in the rangelands of the study region, however, there were some regions which showed a significant increase in NDVImax; those regions were mostly non-vegetated close to settlements.

Aryal et al., (2014) reported a similar shortage of grass in rangelands of Upper Mustang with a decline in palatable grass species. Furthermore, the study suggested that the absence of snowfall and lengthy dry season were the main cause for poor rangeland grass regeneration, which was further exacerbated by increased livestock pressure. Another study conducted by Paudel & Andersen (2010) revealed a decline in 20.2% of the area of the total rangeland of Ghiling (nearby village from Yara). The declining trend was more prominent in southeastern rangelands (winter grazing areas) whereas high altitude summer grazing rangelands showed a positive or stable trend. A similar trend (Figure 5.9d) was seen in our study as rangelands near the village (used for summer grazing) showed a substantial decline in NDVImax compared to high altitude regions.

5.8.4 The Relationship between NDVImax and Rainfall

In order to study the effect of rainfall on vegetation, we calculated pixel-wise Pearson correlation coefficient (r) between growing season maximum NDVI and January – August accumulated rainfall (2000-2016). Given the study area being in the semi-arid region, several rainfall accumulation periods were tested to select the best-accumulated rainfall window (Evans & Geerken, 2004) as explained earlier in Part 5.6.

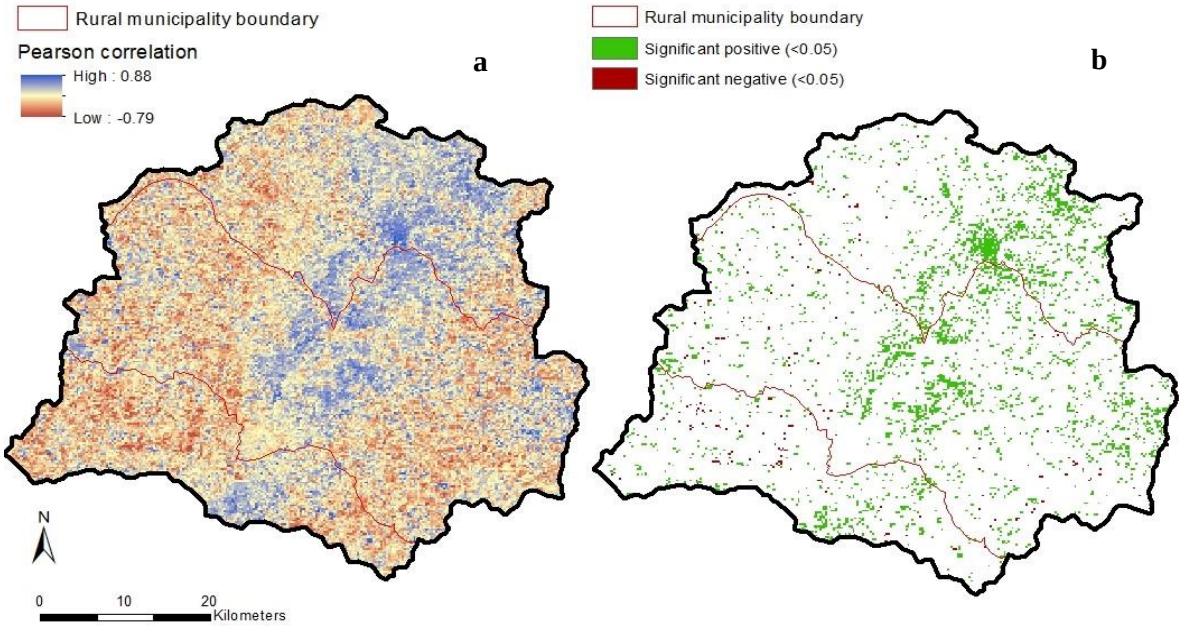


Figure 5.11. (a) Pearson correlation between NDVImax and rainfall (2000 – 2016) and (b) significance at 95% confidence level

The correlation between growing season NDVImax and rainfall is illustrated in Figure 5.11. Based on the results, we found that there was a significant positive correlation between the two parameters mostly in the lower elevation region which covers the agricultural lands and non-vegetated areas. Although some high correlations were observed between NDVI and rainfall in rangeland areas in the north and in the middle-east region, the vegetation cover showed low correlation or no correlation with rainfall in most of the rangelands in the study region.

Figure 5.12 shows the Pearson correlation (r) between NDVImax and rainfall over the studied village. As stated earlier, higher correlation has been observed in lower elevation region (below 4100 m a.s.l.) which mostly comprises of settlement areas surrounded by farmlands, some vegetated areas of species such as *Caragana spp, Lonicera spp, Artemisia spp, Rosa spp, Stipa spp* etc. (Chetri & Gurung, 2004; Paudel & Andersen, 2010) and barren lands. Overall, alpine rangelands (above 4100 m a.s.l.) showed a low correlation. These rangelands mainly comprised of

grass and shrub species such as *Potentilla fruticosa, Kobressia spp, Arenaria bryophylla, Carex spp, and Spirea spp.* (Chetri & Gurung, 2004). However, few rangelands areas extending north to the south showed strong correlations with rainfall. These are mostly located near settlement areas.

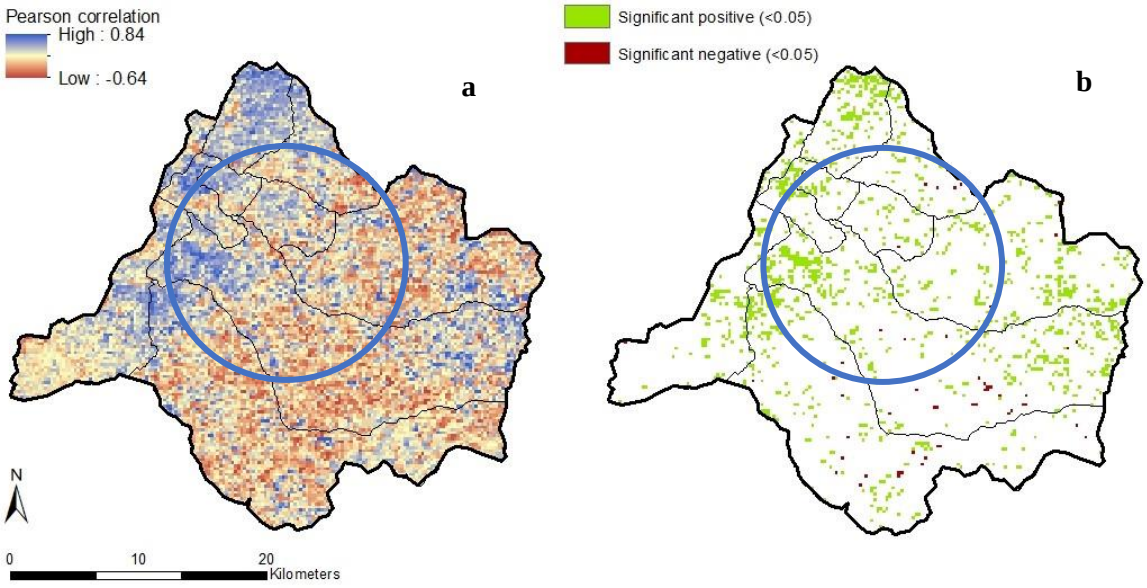


Figure 5.12. (a) Pearson correlation between NDVImax and rainfall (2000 – 2016) and (b) significance at 95% confidence level (blue circle represents rangelands of Yara village)

Low correlation between rainfall and NDVImax in high rangelands can be attributed to the fact that factors other than rainfall affect the growth of vegetation cover in the region. The amount and timing of snowfall have been indicated in as additional factor influencing vegetation growth in Upper Mustang (Craig, 1996; Paudel & Andersen, 2013; Aryal et al., 2014).

During household interviews, local people also mentioned the decrease in the grass in the rangelands was caused by the decline in snowfall in winter. “There is not enough grass in rangelands. In past years, there used to be greenery in rangelands during this time (June-July). Most rangelands are dry with no grass in winters. But even in this time of year, rangelands are

completely dry. This is because we are getting less snowfall in recent years. Last year there was plenty of snowfall," a male respondent from Yara village said.

Anthropogenic factors such as grazing and soil erosion are other factors that can contribute to lower relationships between vegetation cover and rainfall. Additionally, winter snowfall and the water accumulated from permanent snow/ice cover are the other two determining factors for regeneration and growth of vegetation in rangelands; these will be evaluated in Part 5.8.5., and 5.8.6.

5.8.5 NDVI Residuals Trend Analysis

NDVI residuals analysis is the detection of a trend over time which is not explained by rainfall. It provides information on rangeland degradation process. The trend was analyzed spatially to identify regions with a significant increase or decrease of the NDVI residuals. The residuals trend method assumes that regions with significantly declining trends are degraded, while those with increasing trends are improved or not degraded at least (Evans & Geerken, 2004).

Figure 5.13a shows the spatial distribution of NDVI residuals trend in the Upper Mustang region. Both increasing and decreasing trends are shown in the figure. Most of the areas occupied by rangelands showed a decreasing trend whereas the rest showed an increasing trend. However, the decreasing trend was more prominent in most of the rangeland regions.

Further analysis was carried out to identify only areas with a significant increase or decrease at 95% confidence level based on the NDVI residuals. A significant decreasing trend was observed in the rangelands (Figure 5.13b). The decreasing trend was evenly distributed over patches of rangelands in the entire Upper Mustang region. However, the trend was more prominent

in the northern (rangelands of Chhoser, Chhonup and Samzong villages) and eastern (rangelands of Yara and Dheye villages) regions.

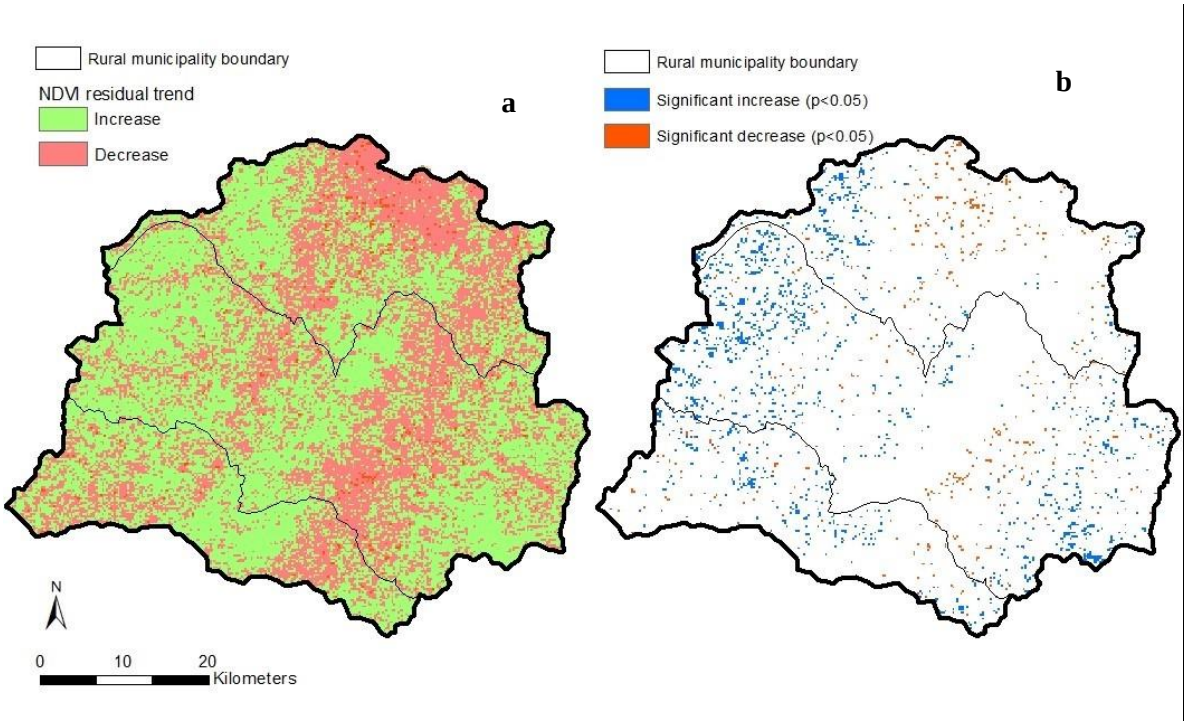


Figure 5.13. (a) Trend of NDVI residuals (2000 – 2016), and (b) significance at 95% confidence level

Figure 5.14a shows the spatial distribution of NDVI residuals trend in the Yara village and surrounding rangelands. The overall decreasing trend has been observed in rangelands which are mostly high-altitude rangelands. Some patches of rangelands located on the eastern side of the village showed a significant decrease in NDVI residuals.

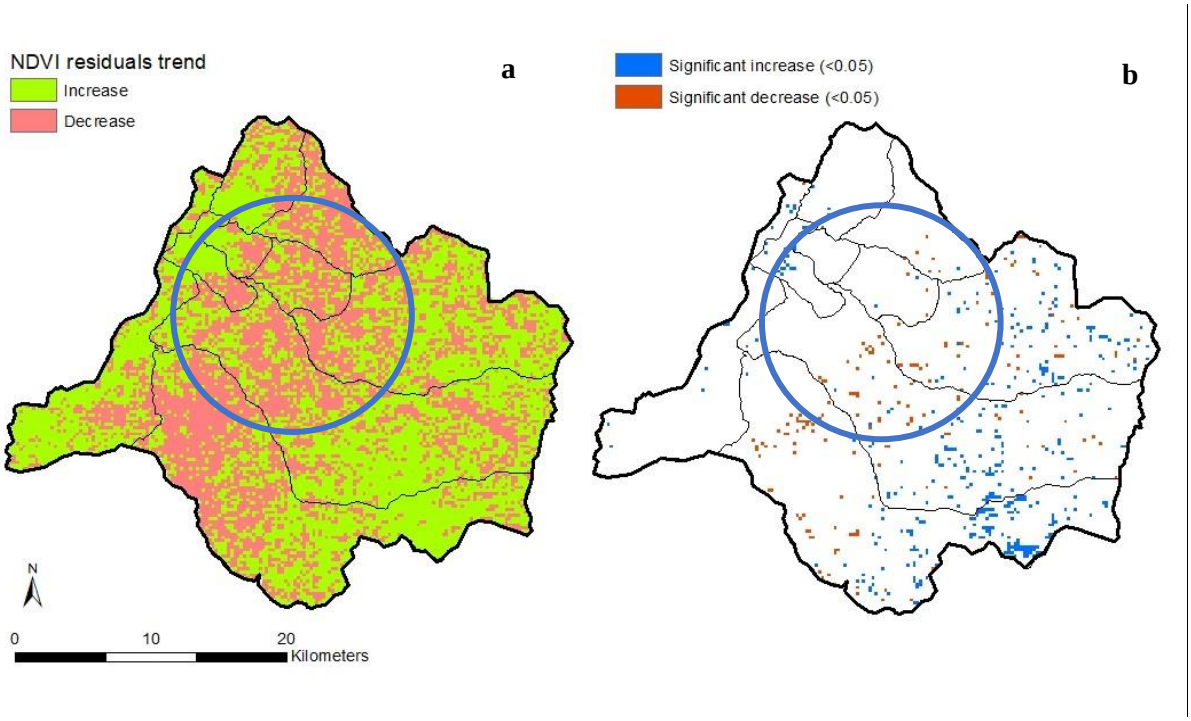


Figure 5.14. (a) Trend of NDVI residuals in Yara (2000 – 2018) and (b) significance at 95% confidence level (blue circle represents rangelands of Yara village)

Furthermore, while comparing the degraded areas illustrated from the NDVI residuals trend (Figure 5.14b) with the areas found directly in NDVImax trends (Figure 5.10d), significantly larger areas of rangelands showed degradation caused by anthropogenic impacts. This decreasing trend could be explained by changes caused by human interference, which indicates the increasing pressure of livestock grazing and natural resource exploitation in rangelands.

Our findings from interviews and available literature point out to the fact that the livestock numbers in the region have significantly increased over the past years despite the limited capacity of the region to support such an increase in livestock. This was a livelihood adaptation strategy for the local population as a result of the agricultural production decline due to the region's water scarcity. In Yara, the number of livestock (goats/sheep mostly) has increased from 1,301 to 1,775 in the last seven years. This increasing trend suggests as a livelihood option by locals in the region.

Clear indications of degraded rangelands were also seen during the field observations. However, our fieldwork did not provide information on the timing and extent of the degradation in rangeland vegetation.

Besides, we also observed a significant increase in NDVI residuals in lower elevation regions which are mostly distributed in settlement areas. These increasing trends of NDVI residuals could be because of agricultural land and areas where tree plantation has been carried out by local people with technical and financial support from ACAP.

5.8.6 Trend of Permanent Snow/Ice Cover in Upper Mustang Region

November to April is considered the snow season in the Upper Mustang region with some early snowfall during September and October in some years. Therefore, to reduce the impact of temporary snowfall, we considered three months of summer; June, July, and August for permanent snow/ice cover analysis as generally the region does not receive snowfall during this period of the year with only occasional snowfall in high altitude regions.

We analyzed a total of 13 images (five images in June including one from May covering the 1st day of June, and 4 each in July and August) for each year from 2000 to 2018. To represent the permanent snow/ice cover, we calculated the snow cover area for each month (Figure 5.15). The month of June represented the least snow/ice cover area while the month of July and August showed some temporary snow cover. This was explained by analyzing the monthly rainfall pattern in the region during the summer. Among these three months, June had less rainfall occurrence

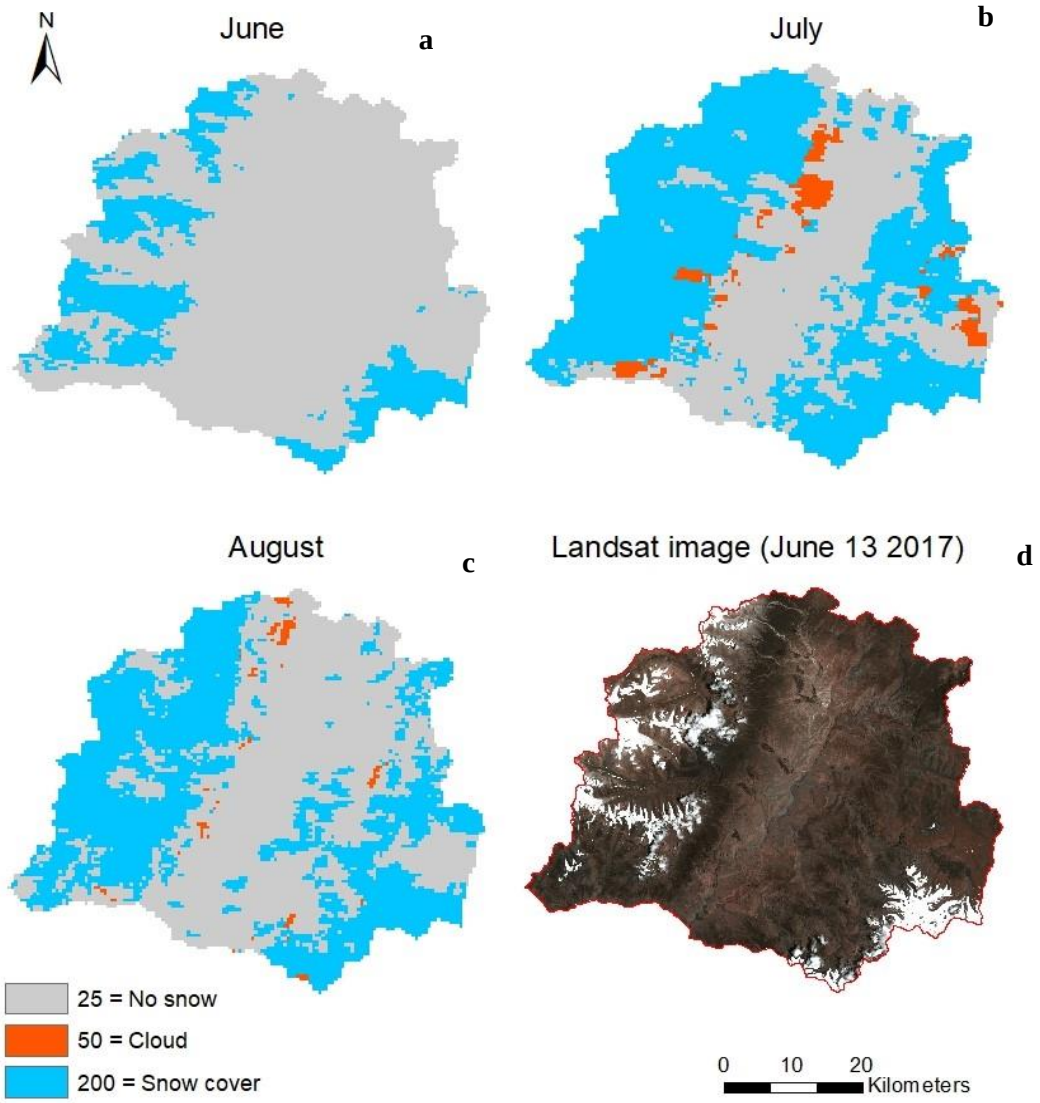


Figure 5.15. MODIS (MOD10A2) images showing the snow cover area for (a) June, (b) July, and (C) August 2017, respectively in Upper Mustang alongside (d) Landsat image of snow cover extent as of June 13, 2017.

whereas the rainfall was recorded higher in July and August months, while in the high elevation region that rainfall could have occurred in the form of snowfall. As a result, there is a high occurrence of snow cover including the temporary snow cover. Therefore, the snow/ice area in June is presumably considered to be the best representation of the permanent snow/ice cover in the region. We calculated both minimum and average snow cover area for the month of June and further analysis was done.

Additionally, we confirmed this time period with the study conducted by the International Centre for Integrated Mountain Development (ICIMOD) in 2012. The study mapped the snow cover area of Nepal using MODIS 8-day snow product (MOD10A2). According to the study, Nepal's average annual snow cover was 21,680 km2 in 2012 (15% of Nepal's total area). The research also revealed that the highest and lowest snow cover months were January and June with 36% and 2% snow cover, respectively (Figure 5.16).

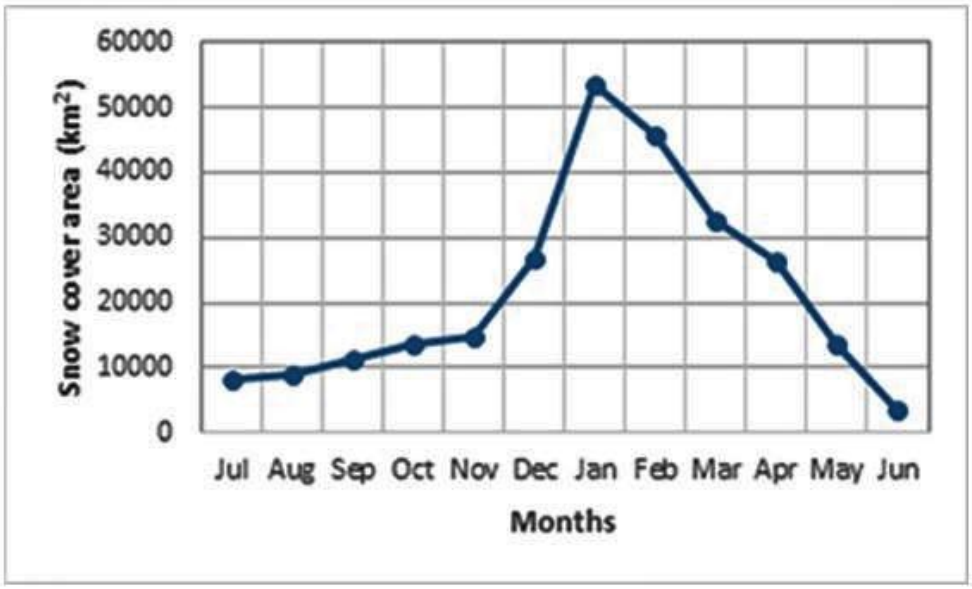


Figure 5.16. Average monthly snow cover of entire Nepal in 2012 (Source: ICIMOD)

Figure 5.17 illustrates the trend of permanent snow/ice cover spanning from 2000 to 2018 in the entire Upper Mustang region. The linear trend indicates that the permanent snow/ice cover is in decreasing order over the 19-year period. The decreasing trend is statistically significant (p-value=0.04) at 95% confidence level. Furthermore, fluctuating snow cover trends can be observed over the years. Maximum snow cover (503.12 km^2) is observed in 2000 whereas the year of 2018 shows the minimum snow cover (271.17 km^2). Other years show varied snow cover area which could be explained by the impact of temporary snowfall in the region.

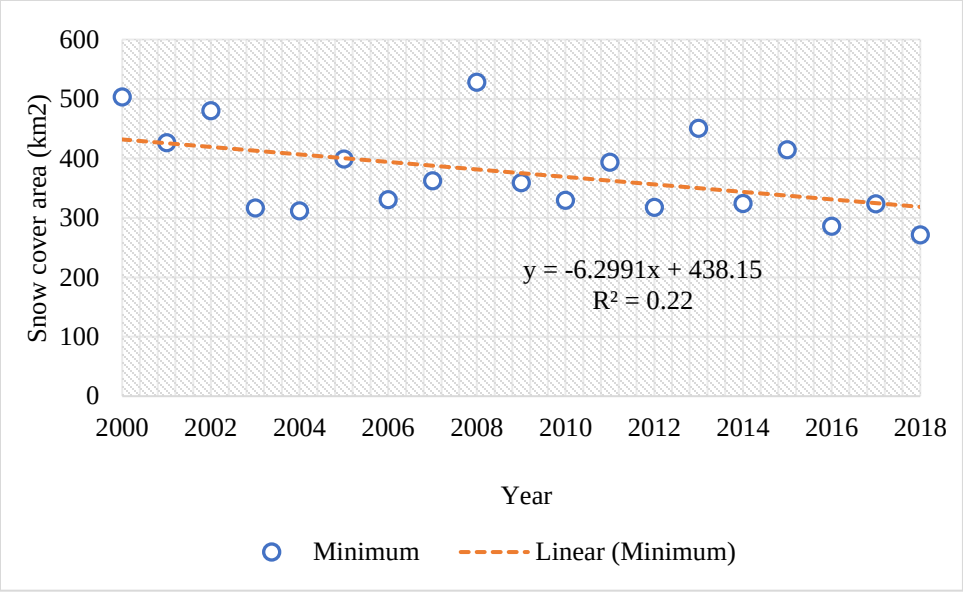


Figure 5.17. Trend of permanent snow/ice cover in the Upper Mustang region (2000-2018)

This declining pattern was consistent with prior research in the region (Paudel & Andersen, 2011; Mishra et al., 2014; Fort, 2015). Moreover, locals also mentioned the snow cover melting in the mountains and the decrease of snowfall in winter. “Nowadays, snow doesn't hold that long. We say that if we see crow-shaped snow in the mountains we get enough water in this month (June). We call it *“Yanghichi”* in our language. But snow in the mountains has melted. If there is enough snowfall in winter, then we can see snow in the mountains. We see just rocks in mountains otherwise,” said an elderly male respondent form Yara village. Many studies link declining snow cover to temperature and the corresponding season precipitation pattern, which is proved to be true in every corner of the world. However, snow accumulation from past seasons also plays a major role in the permanent snow/ice cover contribution (Mishra et al., 2014). Additionally, winds also have a negative effect in sweeping and depositing snow in the mountains (Putkonen, 2004; Yasunari et al., 2010; Paudel & Andersen, 2011; Shrestha et al., 2011).

5.9. Conclusion

The goal of this chapter was to assess the vegetation and snow/ice cover while exploring the relationship with climatic parameters (rainfall). Further, we analyzed the anthropogenic impact on vegetation in the region.

The analysis of climatic parameters showed there has been an increase in temperature in Upper Mustang. Moreover, the minimum temperature is increasing significantly over the past 30 years. Rainfall showed an erratic pattern while the overall trend is in decreasing order. Maximum rainfall period has shifted its timing from July to August in the last 30 years in Upper Mustang. We also observed a declining trend of snow/ice cover in the region.

The time-series analysis of NDVImax showed a significant decline in vegetation in rangelands. The declining trend is evenly distributed over rangelands in the entire Upper Mustang region. Pearson correlation analysis did not show a significant impact of rainfall over vegetation in rangelands. Thus, indicating other factors to be the driving forces of rangeland degradation. The NDVI residuals trend analysis showed a significant decline in rangelands while suggesting the decline as a result of human interference; overgrazing.

Rangelands vegetation in the Upper Mustang region showed a substantially declining trend. Moreover, changing the pattern of climate is also present along with the rapid melting of snow/ice in the mountains.

CHAPTER 6: INTEGRATION, CONCLUSIONS, AND RECOMMENDATIONS

This study utilized a mixed-methods case study methodology while integrating both social and bio-physical research methods to better understand the status and vulnerability of livelihoods in Yara given changing conditions. Using mixed methods helped to gain a wide perspective on the research problem, triangulate across multiple data sources (a key element in case study research); the different methods helped to highlight different aspects and sources of stress to local livelihoods. Moreover, the study aimed to gain an in-depth understanding of the social and bio-physical factors that lead to livelihood vulnerability, livelihood strategies pursued by locals, and its outcomes. By conducting qualitative interviews, we were able to understand various factors affecting the livelihoods of local people and gathered local perspectives of the changes impacting their ways of life. On the other hand, the quantitative bio-physical assessment helped us to triangulate with and further explain the findings from the qualitative approach. This final chapter discusses the key findings while providing recommendations.

6.1 Conclusions from the Triangulation of the Qualitative and Quantitative Components

In the qualitative chapter, we utilized various qualitative data generation methods—semi-structured household interviews, key informant interviews, direct field observations, and archival evidence—to gain an in-depth understanding of local perceptions on driving factors leading to livelihood vulnerability, and adaptation strategies in place to achieve sustainable livelihood outcomes. Given current stressors in the area, Yara village (Upper Mustang, Nepal) provided a suitable case to document how social and biophysical changes impact livelihoods, strategies, and outcomes. Moreover, the sustainable rural livelihoods framework (DFID, 1999) was shown to be

a useful framework to organize and interpret the meanings constructed by the locals in the village that emerged from the open-ended qualitative data analysis.

The social science component of this study provided an in-depth understanding of the various driving factors—social and natural—impacting livelihoods in the area, while the remote sensing and climate data analyses aided in assessing natural factors influencing livelihood vulnerability. Through the interviews, it was evident that locals were concerned and expressed a sense of urgency regarding rangeland degradation, changing climate patterns, along with receding snow/ice cover. The assessment of degradation by ground observations was complex and challenging in many ways given the complicated landscape. As such, biophysical methods—remote sensing and climate data analyses—provided an effective way to monitor, measure, and evaluate the changes in natural conditions. Natural assets and vulnerability are two important components of the sustainable rural livelihood framework. Remote sensing analyses helped to monitor the status of natural assets to inform the assessment of vulnerability conditions. We focused on mapping and analyzing the dynamics of vegetation NDVI in the Upper Mustang region. This analysis helped us to see the historical trend of vegetation productivity. We also utilized climatic datasets to study the trend in rainfall and temperature in order to have an understanding of climate pattern. Moreover, the correlation analysis (Maximum NDVI vs Rainfall) and the NDVI residuals trend analysis provided important information about the multiple drivers—natural as well as anthropogenic—that contribute to the availability and growth of vegetation in the rangelands. While using remote sensing analysis technique for mapping vegetation are generally well known, we were also able to extend the analysis to discriminate between climate impact and anthropogenic impact on rangelands. Furthermore, we were also able to assess the status and trend of permanent snow/ice cover in the region.

In Yara, people combine multiple activities for meeting their sustenance livelihood needs. These activities have supported locals to thrive in such harsh socio-ecological conditions in the region for centuries. Multiple available resources are utilized by locals in Yara including human, social, physical, financial, and natural assets or capitals. Human assets mostly comprised traditional education and skills available in the village. We found increasing awareness among people regarding the importance of formal education to overcome current challenges. Social assets included the norms, traditions, and cultural diversity, which are instrumental in shaping and supporting local livelihoods given harsh conditions. Physical assets are limited in Yara; for example, locals do not have access to electricity. As such, locals rely on solar power as an alternative source of energy, which presents several limitations as expressed by locals and presented in chapter 4. The village has recently been connected through a dirt road network to the headquarters and other southern cities of Nepal. Financial assets are also limited, mostly being income generated from farming, animal husbandry, and seasonal businesses. Currently, locals are increasingly diversifying their livelihoods while seeking more income generation activities. Financial support for development work mostly comes from annual government budget and donations from NGOs and foreign sponsors.

The livelihoods of locals in Yara are heavily dependent on natural assets. For instance, animal husbandry is highly dependent on rangelands. The rangelands provide a foundation for livestock while fulfilling basic subsistence needs, and in some cases, as a source of income via in the form of commercial farming. However, locals seemed concerned about the changing pattern in rangeland ecosystems and the effects on livelihoods. During household interviews, locals stressed their concern over the decreasing trend of grass availability in the rangelands. Moreover, based on the local traditional knowledge, locals linked the decline in snowfall, rainfall, and

receding snow/ice cover as the major cause for the scarcity of grass in rangelands. These local perceptions were further supported by the changing pattern that we observed in rainfall in the region via the biophysical analyses. We observed a significant change in rainfall amount with its erratic pattern in the last three decades. By using remote sensing analyses, we were able to assess the condition of the rangeland's vegetation in the region. Vegetation showed a significant decreasing trend in the last 19 years. The time series analysis of NDVI showed that the vegetation decreased over the study period (2000-2018), in most of the rangelands in Upper Mustang. Based on the correlation analysis between NDVI and rainfall, NDVI was not significantly associated with rainfall, rather suggesting that snow is the major factor driving vegetation growth. The results of NDVI residuals analysis showed that there might be anthropogenic factors such as overgrazing, over-exploitation of bio-resources impacting the vegetation in the rangelands.

Historically, livelihoods of locals in Upper Mustang were heavily dependent on the Tibet region for many activities such as salt trading and livestock grazing (Jackson, 1984; Peissel, 1998; Dhungel, 2002; Tulachan, 2003). Moreover, these practices ended in 1959 after the Chinese invasion of the Tibet region. However, trans-border trade is still in practice currently, which has supported local livelihoods. But, with the development of the dirt road network from the southern part of Nepal to the Upper Mustang region, local people's market system seems to have slowly shifted towards southern cities of Nepal. Additionally, roads and new technologies have made the Upper Mustang region increasingly exposed to the outside world. During interviews, locals also raised great concern that traditional livelihoods and cultures might be endangered because of this exposure to the outside world and the influence of globalization.

Yara village and its inhabitants are extremely susceptible to fragile geography, and rapidly changing conditions. Rainfall is limited in the region. Additionally, the erratic and extreme rainfall

for a short period has been observed in recent years often leading to landslides and flash floods. The increasing trend of harsh northern wind has been prominent in recent years in the region making the daily households work inconvenient as mentioned by locals. The increasing wind was also described as the leading cause of soil erosion in the region (Bernet et al., 2012). Locals mentioned a state of uncertainty in case of air temperature in the village. However, via the climate trend analyses, we observed a warming trend in the last 30 years. Moreover, the minimum temperature increased significantly over the years.

The remote sensing analyses helped us to visualize the historical trend of vegetation in the region, which showed a significant decreasing pattern over the last 19 years. The results suggested the current degradation of rangelands can be attributed to various factors; changing climate and non-climatic factors such as the increasing pressure of livestock on rangelands vegetation in the region (NDVI residuals trend analyses provided some useful information that indicates a role of anthropogenic factors). The increasing number of livestock (mainly sheep and goats) recorded during household interviews also provided evidence to the possibility of overgrazing in the region. Changing climatic conditions have also exacerbated the vulnerability to rangelands. For instance, the decline in snowfall and its shift in timing have caused changes in grass availability in rangelands as mentioned by locals. Moreover, the Pearson Correlation analysis showed less interrelation of rainfall with the vegetation growth suggesting that snow plays a fundamental role in vegetation growth in the rangelands (Craig, 1996; Paudel & Andersen, 2013; Aryal et al., 2014).

Available water resources for irrigation are drying, which has affected the farming system and drinking water in the region leading to increased food and water insecurity. The water loss due to sub-surface flow in the river is a major obstacle for locals given how this regulates water for irrigation. Moreover, because of the absence of water, locals mentioned they are forced to abandon

farmlands. Drinking water is also a big problem since the village has limited water available and the source of drinking water is also in critical condition. Moreover, water resources are mainly fed by seasonal snowfall and streams originated from the mountains. During interviews, locals expressed their concern and a state of urgency regarding declining snowfall and melting of snow and ice cover resulting in the scarcity of water in the village. In addition to the warming trend, Bernet et al., (2012) linked dust particles deposition by increasing wind events as the reason for the declining snow and ice cover. Most importantly, however, the climatic conditions have become less predictable, causing major impacts on traditional livelihood activities such as agriculture and animal husbandry.

Given the vulnerable context, locals have been maintaining their livelihoods by various strategies. For instance, locals mentioned abandoning their farmlands while cultivating limited lands with available water. Similarly, locals have been practicing traditional practice of water management—applying soil in the river to control underground water seepage—in the village to regulate the water for irrigation as they said this practice has been in place for over 30 years. People have also started apple farming in the village. However, locals mentioned that this kind of practice was absent in the past given the heavy snowfall and harsh cold climate. But in recent years, apple farming has become possible with the warming trend and declining snowfall in the region, as mentioned by some local people and key informants. Other than that, locals are also attracted to off-farm livelihood activities. Tourism is one such recent source of income for locals since 1992. Until 1992, Upper Mustang region was a restricted and an isolated region. Locals had limited connection with the southern cities of Nepal. However, with the recent development of the dirt road network, the region has become easily accessible and locals are also benefiting from the opportunity of improved market availability. The young generation is increasingly attracted to

opportunities outside the village including larger cities in Nepal and foreign countries. With all these strategies in practice, locals in Yara are seeking multiple migration opportunities to diversify their livelihoods.

Moreover, since 1992, ACAP has been instrumental in the conservation of natural resources in the region. It has been supporting local livelihoods while providing various technical and financial supports and also by managing tourism in the Upper Mustang region (Key Informant Interview, 05/30/2018). However, the increasing realization of grass scarcity by locals and decreasing trend of vegetation (maximum NDVI) found via our remote sensing analyses, have shown that there is a need for effective planning and policy regulations for the sustainable use of rangelands.

Livelihoods of local people are increasingly in threat to various driving forces, particularly natural and socio-cultural changes. Given the current vulnerability situation, livelihood activities like agriculture and animal husbandry that depend heavily on natural assets are not sustainable. Degradation of natural resources; rangelands, water resources, and farmlands have seriously impacted the traditional livelihoods of local people. Yet, the development of a road network and technologies have supported locals by providing a better market system and more diverse employment opportunities. Local people have benefited from livelihood diversification and agricultural extensification while seeking multiple livelihood strategies such as tourism, winter migration coupled with seasonal businesses, foreign employment, and future sources of income through apple farming. However, vulnerability varies among households in the village, while poorer households with limited access to assets are not able to diversify their livelihoods. Hence, the ongoing changes have exacerbated the gap between households with well off and poorer

households while putting latter at greater risk. As such, institutions and processes should play a central role while recognizing various vulnerabilities and the capacity to react to livelihood threats.

The ongoing change in climate and degradation of rangelands and water resources have called for an urgent need to focus on sustainable use of natural resources to ensure better livelihood outcomes. An effective management plan should be developed and implemented for the sustainable use of available natural resources. Additionally, proper maintenance of water resources should be done, and alternative sources should also be sought. With the ongoing rapid development of road and infrastructures and improvement of communication system, the increasing impact of globalization should also be considered before laying down any development processes. ACAP should implement policies and programs to properly manage tourism while ensuring equal sharing of benefits among households. Moreover, the complexity of the driving forces of livelihoods should be taken into consideration in an integrated and comprehensive way to achieve sustainable livelihoods in the future.

The use of the sustainable rural livelihood framework in this study helped to acknowledge the complex nature of livelihoods and to identify a variety of factors that affect and structure livelihood strategies and outcomes (DFID, 1999; Kollmair & Gamper, 2002). Moreover, further studies in this field would help to more closely identify the context of vulnerability. For instance, a more in-depth investigation of rangelands degradation could be conducted by adding information on grazing patterns in the region. Additionally, future studies can be done in other mountain communities and compared with this study.

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APPENDIX A: ARCHIVAL EVIDENCE PROCEDURE AND PROTOCOL

Written material:

Type of written material:

Date (published, recorded, etc.):

Author(s):

Place where we found the written material:

Guidelines:

1. Describe the written material.
2. Is written material relevant to global changes and livelihood strategies?
3. Summary of content
4. Additional questions/concerns generated by this written material
5. Points to corroborate with other methods

* If written material is central for answering part of a particular research question or to expand/narrow our questioning, make a copy and include write up.

Adapted from thesis proposal by De Urioste-Stone, Gomez & Wongwathana (2002).

APPENDIX B: KEY INFORMANT INTERVIEW PROTOCOL

Time of interview:

Date:

Interviewer:

Interviewee ID:

Interviewee activity or characteristics:

Materials: Tape recorder, microphone, camera, sheets, and markers.

Introduction: Namaste/Hello! My name is Sandesh Shrestha, I am from Nepal, and I am a graduate student in the School of Forest Resources at the University of Maine, United States. I am currently conducting a study to learn about the livelihoods of mountain people, to understand how global change is impacting people's livelihoods, and what strategies have been initiated to cope with the changes.
If you will allow me, I would like to interview you. The interview will take approximately one hour; if you agree, I will tape-record the interview, and take photographs and video tape some of the interview sessions.

Questions

1. How long have you been working in this specific organization? What type of activities do you conduct here?

2. What are the major livelihood activities of people living in the community?

3. Have you observed any changes in the area over the past 10-15 years? If so, what are they?

4. In your perception, are there any changes in climate (temperature, rainfall, snowfall, water resources, and permanent snow cover)?
- How has the natural environment been impacted (positive, negative) by those changes?
- How have communities been impacted (positive, negative) by those changes?

5. In your view, what have communities done to adapt/cope with the impacts of the changes in the last 10-15 years?

6. In your view, what other things can be done by community members to adapt/cope with the changes?

7. Have you/your organization supported in any adaptation strategies or contributed to helping local communities respond to the changes? If so, what kind of concrete support do you offer (extension services, knowledge transfer, technological support, income opportunities, and so forth)?

8. Is there anything else you would like to mention in terms of changes, livelihood activities that we have not talked about?

9. Who else would you recommend talking to that could give us information about the communities, and the issues faced? Someone that may have a different perspective than you? Someone that has worked a lot in the region or will have a lot of information to share?

Remember to thank the participants for coming to the meeting and for the information provided. Do not forget to emphasize on the confidentiality of their information.

Adapted from Framework for community-based climate vulnerability and capacity assessment in mountain areas, ICIMOD (Macchi, 2011).

APPENDIX C: SEMI-STRUCTURED HOUSEHOLD INTERVIEW PROTOCOL

Time of interview:

Date:

Place:

Interviewer:

Interviewee ID:

Interviewee activity or characteristics:

Materials: Tape recorder, microphone, camera, sheets, and markers.

Introduction: Namaste/Hello! My name is Sandesh Shrestha, I am from Nepal, and I am a graduate student in the School of Forest Resources at the University of Maine, United States. I am currently conducting a study to learn about the livelihoods of mountain people, to understand how global change is impacting people's livelihoods, and what strategies have been initiated to cope with the changes.
If you will allow me, I would like to interview you. The interview will take approximately one hour; if you agree, I will tape-record the interview, and take photographs and video tape some of the interview sessions.

Questions

1. How long have you been in this community?

2. What type of activities do you and your family practice currently for living? How long have you and your family practiced each of these activities?

3. What kind of natural resources do you depend on for your daily activities? What purpose? What are the institutional arrangements within the community for the management of, or decision making about natural resources?

4. Have you observed any changes in community in last 10-15 days? If so, what are those? How have these changes impacted (positively, negatively) you, your family, and community?

5. Have you noticed any difference in climate (rainfall, snowfall, temperature, wind) in last 10-15 years? If so, what kind of changes (time, duration, intensity, frequency)? What do you think are the reasons for these changes? How have these changes impacted your livelihood activities?

6. Based on the changes you mentioned above, have there been any changes in your livelihood activities in last 10-15 years? If so, how has it changed? What are the drivers of such change? How have you, your family, and community adapted to these changes?

7. Have you received any support from government, NGOs or any other organizations? If so, what are they? What do you think about the interventions that already happened in your community (if any)? Which one worked, and which ones did not? Why?

8. How do you perceive the future of your family and community? In addition to the ones you mentioned above, which strategies and mechanisms (including technologies, information, infrastructure, institution, and livelihood activities) do you think would help you most to alleviate the current difficulties you are facing?

Remember to thank the participants for coming to the meeting and for the information provided. Do not forget to emphasize on the confidentiality of their information.

Adapted from Framework for community-based climate vulnerability and capacity assessment in mountain areas, ICIMOD (Macchi, 2011).

APPENDIX D: FIELD OBSERVATION PROCEDURE AND PROTOCOL

Before the observation
Step 1: Define the purpose and objectives (what I want to study e.g. Livelihood, adaptation to various environmental changes)

Step 2: Identify setting with greatest potential (place, activity, individuals/groups, etc.)

Step 3: Develop observation guidelines

Step 4: Draft the observation form

During the observation
Step 5: Observe on-site and record data following the protocol

After the observation
Step 6: Write reflective notes on the protocol form immediately (if possible) after finishing an observation

Step 7: Transfer data on the form and in the reflective journal to the database

Step 8: Analyze data (NVivo 12) or alternative method if necessary)

Step 9: Create the next protocol addressing areas to further explore

Field observation protocol
Time of observation:
Date:
Observer:
Settings:
Objective of observation:
To identify livelihood strategies of people, activities related to daily livelihood
To identify symbols and signs (can be words, images, feelings, and behaviors) that related to livelihood
General guidelines for note-taking:
- What people do for daily living
- Household works
- Farming

Adapted from thesis proposal by De Urioste-Stone, Gomez & Wongwathana (2002)

APPENDIX E: KEY INFORMANT INTERVIEW CONSENT FORM

You are requested to participate in a research project being conducted by Sandesh Shrestha, a graduate student, and Dr. Sandra De Urioste-Stone, a faculty member, in the School of Forest Resources at the University of Maine, United States. The goal of this project is to learn about the livelihoods of mountain people, to understand how global change is impacting people's livelihoods, and what adaptation strategies have been initiated by local people to cope with the changes. You must be at least 18 years of age to participate.

What will you be asked to do?

I will schedule an interview with you and request your participation. The interview will take approximately one hour. With your permission, I will tape-record the interview, and take photographs and video tape some of the interview sessions. I would also like to request your permission to use photographs and videos during presentations and publications of this study. Presentations about the study may include thesis defense, national and international conferences and seminars.

If you don't want photographs or videos to be used for publication and presentation purposes, you have the right to request the investigator not to include them. In any publication or presentations, your names will not be revealed. No pictures will be associated with specific quotes provided in the text.

Example of potential interview questions

- How long have you been working in this specific organization?
- What are the key responsibilities of your job? How much do you work in these communities? What type of activities do you conduct there?
- Have you observed any changes in the area over the past 10-15 years? If so, what are they?

Voluntary

At any time throughout the interview, you can stop and refrain from answering questions you do not want to address.

Risks

Except for your time and inconvenience, there are no risks to you from participating in this study

Benefits

While this study may have no direct benefit to you, this research may help in informing future policy and decisions to sustain livelihoods of communities in light of global change.

Confidentiality

Interview responses will be coded with identification numbers and an electronic key used to link names to identification numbers and will be kept on a password protected computer using software that provides additional security, only to be accessed by the investigators. The electronic key linking participants' identities to data will be kept for one year (August of 2019). Audio recordings, photographs, and videotapes will be kept in a password protected computer and will be destroyed after five years (August of 2023). Transcribed data will be kept indefinitely in a password protected computer, only to be accessed by investigators.

Contact information

If you have any questions about this study, please contact:

Sandesh Shrestha at (207) 5659 5590; sandesh.shrestha@maine.edu; or 231 Nutting Hall, University of Maine, Orono, ME 044669-5755.

Dr.Sandra De Urioste-Stone at (207) 581 2885; sandra.de@maine.edu; or 237 Nutting Hall, University of Maine, ME 04468-5755

Communications will be provided both in English and Nepali.

If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, (207) 581 1498 or (207) 581 2657 (or e-mail: umric@maine.edu).

APPENDIX F: SEMI-STRUCTURED HOUSEHOLD INTERVIEW CONSENT FORM

You are requested to participate in a research project being conducted by Sandesh Shrestha, a graduate student, and Dr. Sandra De Urioste-Stone, a faculty member, in the School of Forest Resources at the University of Maine, United States. The goal of this project is to learn about the livelihoods of mountain people, to understand how global change is impacting people's livelihoods, and what adaptation strategies have been initiated by local people to cope with the changes. You must be at least 18 years of age to participate.

What will you be asked to do?

I will schedule an interview with you and request your participation. The interview will take approximately one hour. With your permission, I will tape-record the interview, and take photographs and video tape some of the interview sessions. I would also like to request your permission to use selected photographs and videos during presentations and publications of this study. Presentations about the study may include thesis defense, national and international conferences and seminars.

If you don't want photographs or videos to be used for publication and presentation purposes, you have the right to request the investigator not to include them. In any publication or presentations, your names will not be revealed. No pictures will be associated with specific quotes provided in the text.

Example of potential interview questions

- How long have you lived in this community?
- How would you describe your community?
- What are your daily major activities?

Voluntary

At any time throughout the interview, you can stop and refrain from answering questions you do not want to address.

Risks

Except for your time and inconvenience, there are no risks to you from participating in this study

Benefits

While this study may have no direct benefit to you, this research may help in improving understanding and awareness of global change and in increasing the adaptive capacity of communities to cope with potential changes.

Confidentiality

Interview responses will be coded with identification numbers and an electronic key used to link names to identification numbers and will be kept on a password protected computer using software that provides additional security, only to be accessed by the investigators. The electronic key linking participants' identities to data will be kept for one year (August of 2019). Audio recordings, photographs, and videotapes will be kept in a password protected computer and will be destroyed after five years (August of 2023). Transcribed data will be kept indefinitely in a password protected computer, only to be accessed by investigators.

Contact information

If you have any questions about this study, please contact:

Sandesh Shrestha at (207) 5659 5590; sandesh.shrestha@maine.edu; or 231 Nutting Hall, University of Maine, Orono, ME 044669-5755.

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Communications will be provided both in English and Nepali.

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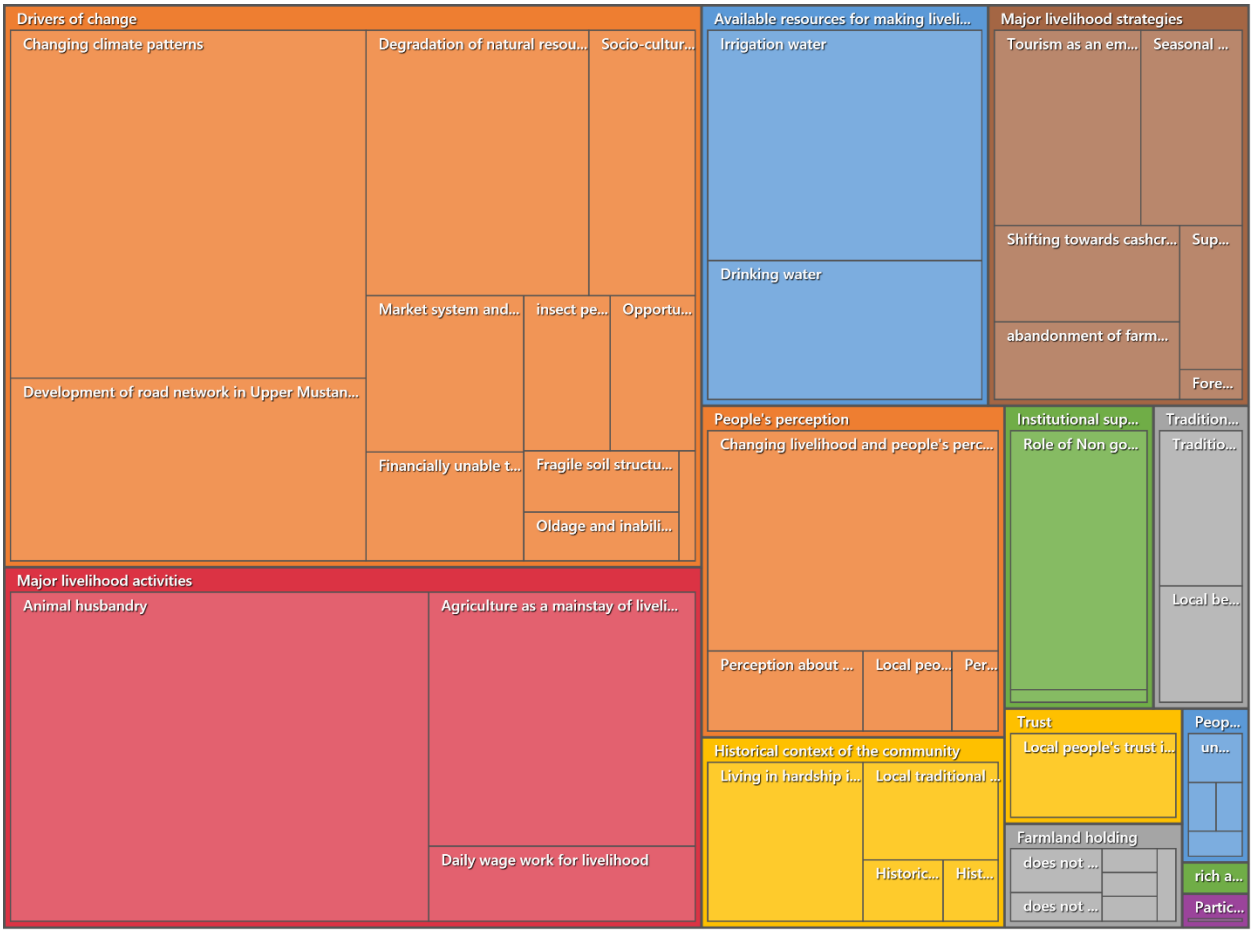
APPENDIX G: QUALITATIVE ANALYSIS OUTPUTS

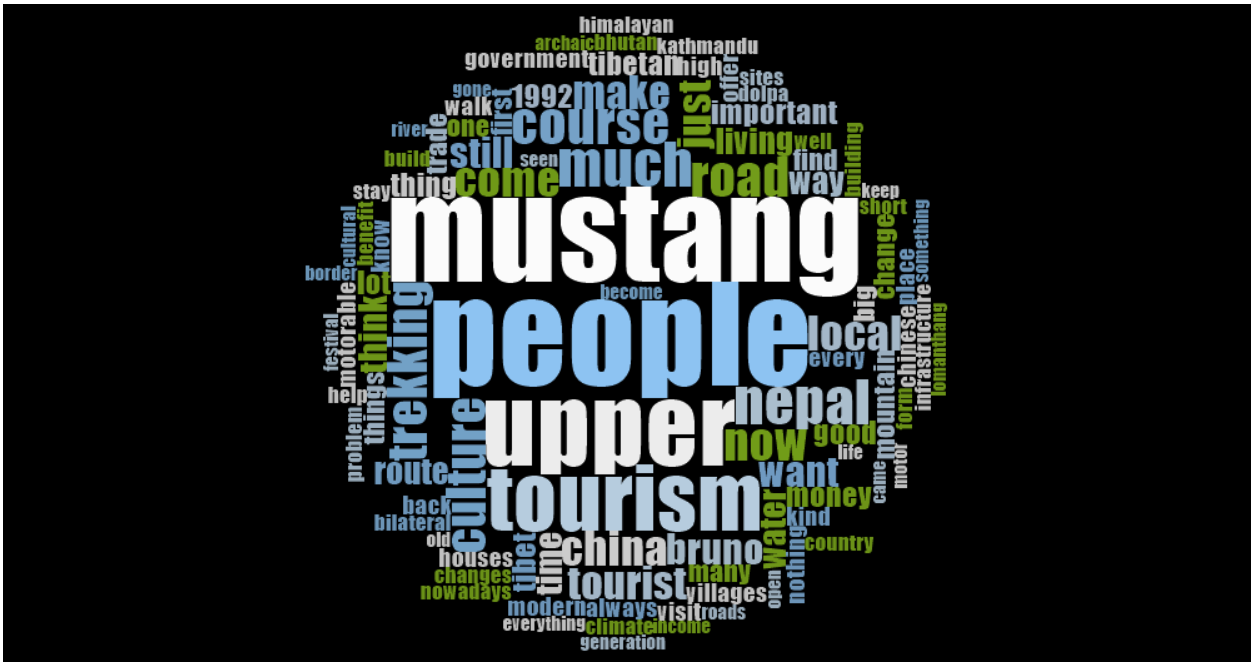
Matrix 1. Livelihood activities of two households

	Agriculture	Animal husbandry	Tourism
YHH02 Age Group = 20 - 30 Education level = Completed primary school Gender = Female Number of family members = 3 - 6	We don't have farmland. We are not engaged in any farm works. We did not have any farmland for our past two generations. We bring most of the foods from market.	We have kept some goats. Grass is not enough in pasture land. So, we buy corn from market and feed them…. People are increasing the number of livestock anyway.	I run a hotel for tourist now. I used to run campsite before. But nowadays, tourist like to stay in hotel rooms. Therefore, we have built some rooms…People are attracted towards tourism more now.
YHH10 Age Group = 40 - 50 Education level = Completed primary school Gender = Male Number of family members = 3 - 6	We also have agriculture land. We plant vegetables on one of our farmland and wheat on the rest. We have enough farmland but, due to lack of water we cannot plant all of them. We have abandoned farmland across this stream as you can see. Agricultural crops are not sufficient for our household.	We have kept goats and sheep. We take them to pasture land for grazing in daytime. But only grass from pasture is not enough to feed them. We have to buy food from market and feed them in the morning and at night. Grass has decreased in pasture. Additionally, people are keeping more goats and sheep nowadays. It has increased profit but there is also high cost for rearing them.	During peak season, visitors hire our horses to get to the holy Damodar kunda lake. I make some earning from providing this service for visitors.

Matrix 2. Hierarchy chart displaying the categories generated from household interviews



Matrix 3. Word cloud capturing the ideas brought up in a key informant interview



Matrix 4. Perception on various climate variables among interviewees

Interviewee	Snowfall	Rainfall	Temperature	Wind
YHH01	We don't get that much snow in winter now. It used to snow a lot before and used to be very cold.	We used to get plenty of rainfall before. Because of that our pasture land used to be full of grass. But, now rainfall is very limited.	…Similarly, temperature has also increased. It is warm as compared to previous years.	I did not experience harsh wind before. But, nowadays we get a lot of wind in village.
YHH02	We used to get heavy snow in winter in past years. We had to remove snow with shovel from our rooftops. But, snowfall is very rare now. We only had one snowfall this year in very small amount which melted right away.	Rainfall has decreased in recent years. It is supposed to be raining now (June-July) but, it is not.	Our village has the warmest climate out of all villages in Upper Mustang. It is warm here. I do not feel any changes in temperature. It is same as it was used to be before.	We are getting too much wind nowadays which was very rare before.

APPENDIX H: IRB APPROVAL

- ***KEEP THIS PAGE AS ONE PAGE – DO NOT CHANGE MARGINS/FONTS!!!!!!!!!***
- ***PLEASE SUBMIT THIS PAGE AS WORD DOCUMENT***

APPLICATION FOR APPROVAL OF RESEARCH WITH HUMAN SUBJECTS
Protection of Human Subjects Review Board, 400 Corbett Hall

(Type inside gray areas)
PRINCIPAL INVESTIGATOR:
Sandesh Shrestha EMAIL:
sandesh.shrestha@maine.edu
CO-INVESTIGATOR: EMAIL:
CO-INVESTIGATOR: EMAIL:
FACULTY SPONSOR: Dr. Sandra De Urioste-Stone EMAIL:
sandra.de@maine.edu (Required if PI is a student):
TITLE OF PROJECT: Mountain Livelihoods and Adaptation Strategies in Response to Global Changes; A Case Study of Upper Mustang in Nepal
START DATE: 05/08/ 2018 PI
DEPARTMENT: SFR FUNDING
AGENCY (if any):

STATUS OF PI: FACULTY/STAFF/GRADUATE/UNDERGRADUATE G (F, S, G, U)

1. **If PI is a student, is this research to be performed:**

☐ **for an honors thesis/senior thesis/capstone?** ☒ **for a**
☐ **master's thesis? for a doctoral dissertation?** ☐ **for a**
☐ **course project? other (specify)**

2. **Does this application modify a previously approved project? N (Y/N). If yes, please give assigned number (if known) of previously approved project:**

3. **Is an expedited review requested? Y (Y/N).**

Submitting the application indicates the principal investigator's agreement to abide by the responsibilities outlined in Section I.E. of the Policies and Procedures for the Protection of Human Subjects.

Faculty Sponsors are responsible for oversight of research conducted by their students. The Faculty Sponsor ensures that he/she has read the application and that the conduct of such research will be in accordance with the University of Maine's Policies and Procedures for the Protection of Human Subjects of Research. REMINDER: if the principal investigator is an undergraduate student, the Faculty Sponsor MUST submit the application to the IRB.

Email this cover page and complete application to UMRIC@maine.edu

** **FOR IRB USE ONLY** **Application # 2018-04-08 Review (F/E): E**

ACTION TAKEN:

☐ **X** **Judged Exempt; category 2 Modifications required? Y Accepted (date) 5/4/2018**

☐ **Approved as submitted. Date of next review: by Degree of Risk:**

☐ **Approved pending modifications. Date of next review: by Degree of Risk:**

Modifications accepted (date):

☐ **Not approved (see attached statement)**

☐ **Judged not research with human subjects**

FINAL APPROVAL TO BEGIN 5/4/2018

BIOGRAPHY OF THE AUTHOR

Sandesh Shrestha was born in Mustang, Nepal on June 26, 1993. He spent his early childhood in Tukuche, a rural Himalayan village in Mustang. He moved to Kathmandu (Nepal's capital city) to continue his high school education. After completing high school, he got admission for undergraduate study at the Institute of Forestry in Pokhara in 2011. He graduated in 2015 with a Bachelor of Science in Forestry degree.

Sandesh worked as a Research Assistant in joint research conducted by Chiba University and Institute of Forestry, Pokhara where he studied changes in forest ecosystem and people's livelihood in Nepal. He also has experience in working with the local communities of Upper Mustang in Nepal.

Sandesh is a candidate for Master of Science degree in Forest Resources from the University of Maine in August 2019.