University of Southern Queensland

THE SOCIO-ECOLOGICAL IMPACTS OF STRUCTURAL CHANGES IN THE TRANSHUMANCE SYSTEM OF THE MOUNTAINOUS AREAS OF NEPAL

A Dissertation Submitted by

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Abstract

Traditional social-ecological systems such as pastoralism can be subject to major and rapid changes, resulting in adverse social, economic, cultural and ecological impacts. Transhumance, a type of pastoralism based on seasonal and recurring movement of livestock has been undergoing unprecedented changes. In the high Himalayas, transhumance is a threatened system due to social-economic and cultural transformations brought by globalisation, shifts from subsistence agriculture (e.g. grazing) to multi-functional land use (e.g. tourism and biodiversity conservation), conservation policies and practices, and climate change. Understanding the nature, extent and impacts of these changes will inform both policy and practice. However, knowledge of the current status of the transhumance system and its socio-economic, cultural and ecological significances is very limited. This study on the transhumance system conducted in or near three mountainous protected areas of Nepal Himalayas addresses the knowledge gap.

The study integrated both social and ecological components of transhumance systems using a system thinking approach. The study was multi-disciplinary in nature and applied mixed methods using a range of tools and techniques for data collection and analysis. Socio-economic data were collected by household surveys, focus group discussion, informal interviews and key informants interviews. The ecological data were collected from the rangelands sites using horizontal transects of grazed areas to collect data on grazing intensity, species richness and other environmental variables.

The study revealed that the transhumance system is a major source of household income of herders and is also embedded with culture and traditions. The results did not support the notion that transhumance grazing is necessarily detrimental to biodiversity. Though the species richness (α-diversity) was low and nitrophilous and grazing tolerant plants were abundant nearer to the *goths* (semi-permanent stopping and camping points), the highest species richness and occurrence of rare species at mid and further distances from *goths* within 800 m transects suggest that adverse impacts were confined to very limited areas near *goths.* In fact, the results indicate that light or medium grazing intensity promotes species richness and composition in other areas.

Globalisation, particularly tourism and labour migration, state conservation policies and practices and climate change were the major drivers of change to the transhumance system. However, the intensity of pressures from those drivers on the systems varied across sites. Tourism and labour migration created shortage of labour for transhumance systems and reduced local economic dependency on such systems. The conservation programs run by government agencies produced unintended outcomes in the transhumance system. It was found that the operational freedom and flexibility of transhumant herders were reduced by conservation policies and programs creating negative attitude and perceptions among herders towards different schemes of conservation. The trends of key climatic variables (temperature and precipitation) and

perceived changes in different biophysical indicators by herders indicated that the climate change has emerged as an additional threat and has the potential to impact different components of transhumance systems (rangelands, livestock and herders).

Herders perceived that fewer households were involved in the transhumance system, herd sizes had decreased, movement patterns have been changed, dependency on transhumance was reduced and the involvement of younger generations in transhumance systems has declined. These changes can decouple social and ecological subsystems that can induce adverse social-ecological impacts. The likely social impacts are decreased livelihood options, reduced agricultural production, loss of customary lifestyle and traditional knowledge and culture. The potential ecological impacts from the loss of transhumance systems can be on biodiversity, vegetation and land use, and ecosystem functions and services.

Complete collapse of the transhumance system could be detrimental, however, some level of transhumance could be desirable. How herders and transhumance systems respond to multiple change pressures will depend on how future policy decisions will support transhumance and whether transhumance systems appear beneficial and attractive compared to other available livelihood options. The incentives to motivate herders by creating a lucrative environment for doing transhumance such as by introducing value addition technologies, certifying and levelling transhumance products, and integrating with alternate livelihood options can encourage some families to continue transhumance.

Certification of dissertation

I certify that the ideas, results, analyses and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. It is also certified that the work is original and has not been previously submitted for any other academic award.

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Abbreviations

˚C	Degree Celsius
ANOVA	Analysis of variance
BZ	Buffer Zone
CA	Conservation Area
CAMC	Conservation Area Management Committee
CAMR	Conservation Area Management Rules (1996)
CBS	Central Bureau of Statistics
CCA	Canonical Correspondence Analysis
CF	Community Forest
CFUG	Community Forests Users Group
CVI	Climate vulnerability index
DCA	Detrended Correspondence Analysis
DHM	Department of Hydrology and Meteorology
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
EXP	Expectations
FGD	Focus group discussion
GCA	Gaurishankar Conservation Area
GDP	Gross domestic product
GoN	Government of Nepal
HH	Household
HKH	Hindu Kush-Himalaya
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
km	kilometre
KNP	Khaptad National Park
LU	Livestock unit
LVI	Livelihood vulnerability index
m asl	metre above sea level

m	metre
MoAC	Ministry of Agriculture and Cooperatives
n.a.	not applicable
NARC	Nepal Agricultural Research Council
NAST	Nepal Academy of Science and Technology
NPA	Negative perception and attitude
NP	National Park
NPWCA	National Parks and Wildlife Conservation Act (1973)
NTNC	National Trust for Nature Conservation
PA	Protected area
PAR	Participation
PCA	Principle Component Analysis
PPA	Positive perception and attitude
SES	Social-ecological system
SNP	Sagarmatha (Mt. Everest) National Park
sq km	square kilometre
TSES	Traditional social-ecological system
UNESCO	United Nation Educational, Scientific & Cultural Organization
VDC	Village Development Committee
WWF	World Wide Fund
yr	year

Glossary of Nepalese words

aul-chana	a local term for winter grazing areas in KNP
bari	upslope rain fed agricultural land
chauri	a female crossbreed of yak/nak with cow/bull and vice-versa
churpi	traditional cheese made from buttermilk
dasara Mela	a festival celebrated in far-Western Nepal
dashain	the biggest festival for Hindu in Nepal
deuda	a famous cultural song and dance in far-Western Nepal
dhami-jhakri	traditional witch doctor
ghunsa	downslope winter settlements (local Sherpa term used in SNP)
goth	semi-permanent shelter used by herders
jestha Purnima	full moon day in May
jokpyo	a male cross breed of yaks/nak with cows/bulls and vice-versa
jyaladari	a system where labour are paid in cash or kind on a daily basis
karmakanda	ritual activities after the death of people
kharka	rangelands far from the settlement areas
lekh-chana	a local term for summer grazing areas in KNP
nawa pratha	traditional system of electing *nawa*
nawa	elected member from the village meeting to regulate livestock
patans	flat grazing areas(rangelands) in the mountains
purji	written permission to graze livestock
samudayik ban	community forest
tatha bata	local elites
vakal garne	advance promising with goddess to offer something if the wish comes true
yersa	upslope summer settlements (local Sherpa term used in one site)

Publications during the PhD

1. List of journal papers

Aryal S., Cockfield G., Maraseni T.N. (2015). Perceived changes in climatic variables and impacts on the transhumance system in the Himalayas. *Climate and Development*. (published online and awaiting assigning volume and issue). http://dx.doi.org/10.1080/17565529.2015.1040718

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2. List of conference and workshop papers

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Chapter 1 : Introduction

1.1. Background

Traditional social-ecological systems (TSESs) can persist in particular configuration of social-cultural, institutional and environmental factors for hundreds of years (Janssen *et al.* 2007) providing a range of ecosystem services and functions (Carpenter *et al.* 2001; Huntsinger & Oviedo 2014; Martín-López *et al.* 2011). They have long continuous history with relatively consistent practices and link people and nature. Such TESs are however, facing a range of challenges from global social and environmental change (Abel *et al.* 2006; Young *et al.* 2006). Given rapid changes in human and biophysical processes, many TSESs may break down by the end of this century (Ostrom 2007b). The loss or decline of such systems may be irreversible (Marini *et al.* 2011) and this is likely to affect ecosystem services and livelihood of people embedded in the relevant systems. Small farms (Aubert & Perrier-Cornet 2009; Hazell 2005) and different types of pastoral systems (Ayantunde *et al.* 2011; Steinfeld *et al.* 2006; Thornton *et al.* 2009) are examples of TSESs subject to significant forces for change.

Transhumance is a form of pastoralism in which livestock are moved between fixed points to utilize seasonal availability of grazing resources (Ayantunde *et al.* 2011; FAO 2001; Nyssen *et al.* 2009). Transhumance evolved as a strategy to harness low and seasonal production of grazing resources distributed over large areas having harsh climatic conditions (Manzano-Baena & Casas 2010; Moktan *et al.* 2008). It is practised by people from settled communities in combination with arable agriculture (Jones 2005). Transhumance differs from other types of pastoralism such as nomadism and agro-pastoralism because of its periodicity, regularity and mobility combined with a sedentary base. Nomadism is practised by pastoral people having no fixed residence and their movements are more opportunistic based on the availability of pasture resources that may vary from year to year. Agro-pastoralism is practiced by settled pastoralists who cultivate sufficient areas to feed their family and graze livestock within a finite area (Jones 2005).

Similar to other TSESs, transhumance has a long history (Ruiz & Ruiz 1986) and is based on endogenous knowledge and culture (Oteros-Rozas *et al.* 2013a). It has been variously argued that transhumance system and traditional knowledge are important for preserving cultural landscapes (MacDonald *et al.* 2000; Rescia *et al.* 2008), conserving biodiversity (Olea & Mateo-Tomás 2009), preventing fire (Kerven & Behnke 2011; Ruiz-Mirazo *et al.* 2009), and regulating ecosystem function and services (Oteros-Rozas *et al.* 2012; Oteros-Rozas *et al.* 2014). With such systems being eliminated or declined (Banerjee 2009; Namgay *et al.* 2014), some or all of those benefits may be lost. Pastoral systems (including transhumance) have been constrained globally (Dong *et al.* 2011) by shortages of labor (Banerjee 2009; Namgay *et al.* 2014; Shaoliang *et al.* 2007), agricultural intensification (Bhasin 2011), tourism enhancement (Akis 2011; Hoffman & Rohde 2007; Özden *et al.* 2004), rangeland privatisation and nationalisation (Bassett 2009; Fu *et al.* 2012), property right alteration (Beyene 2009) and climate change intensification (Martin *et al.* 2014; Namgay *et al.* 2014; Nardone *et al.* 2010; Thornton *et al.* 2009). Compounding pressures include change in national land-use policies that promotes intensive agriculture and settlement in grazing land (Bassett 2009; Herzog *et al.* 2005; Kamara *et al.* 2004; Shaoliang *et al.* 2007) and conservation policies that restrict traditional grazing inside national park and reserves (Colchester 2004; Kala & Shrivastava 2004; Namgay *et al.* 2014; Rao *et al.* 2003a; Urgenson *et al.* 2014). Transhumance in mountainous regions is especially vulnerable to these systematic change pressures.

In the transhumance system, the movement of livestock occurs between summer and winter pastures (Aitken 1945; Manzano-Baena & Casas 2010) and is one of the most important livelihood activities in high altitude areas of the Himalayas where it has been practiced since early human settlement (Bhasin 1998; Moktan *et al.* 2008). Customary rules and informal institutions play an important role for the sustenance of transhumance systems (Dong *et al.* 2009a; Rao *et al.* 2003b). The transhumance systems in the mountainous areas of Nepal are some of the traditional pasture management strategies (Karki & Mcveigh 1999; Sharma 2006) and considered as a herder's rational approach to livestock production utilizing seasonal production of pastures at different altitude (Chetri *et al.* 2011).

The northern mountainous part of Nepal where transhumance systems were practised has witnessed change in socio-economy, policies and climate (detailed in section 1.2). These changes have the potential to affect both social and ecological systems of the transhumance and it is important to know how these changes have affected transhumance systems and how elimination or decline of the systems for any reasons operates in the mountainous region of Nepal. The study of transhumance systems, including their socio-economic, cultural and ecological aspects, helps to understand whether or not their sustainability is desirable and what would be possible strategies to sustain them. This study, therefore, aims to study the contemporary transhumance system in the northern mountainous areas of Nepal. Some of the issues that highlight the needs of this study are given in the next section.

1.2. Statement of the problems

The mountainous area of Nepal has experienced changes in socio-economy, policy and climate. First, there are socio-economic changes driven by globalisation. Globalisation has the potential to change labour availability, income opportunities, goals of livestock rearing and the indicators of social prestige in rural societies. In relation to labour availability, Nepal is ranked third in the contribution of remittances to the total gross domestic product (GDP) with more than 25% from that source (*Migration and Development Brief 21* 2013). A total of 5, 21,878 labour permits were issued in 2013/14 from Nepal (MoLE 2014). This official figure still seriously underestimates the actual figure (Seddon *et al.* 2002). On the one hand, labour migration has offered additional income opportunities and diversified household income, but on the other hand, it has created labour shortage, increased land abandonment and decreased production from traditional farming systems (Ghimire & Aase 2007; Khanal *et al.* 2015). This has also affected the viability of some highland communities (Childs *et al.* 2014) and traditional farming systems are at the forefront to suffer from these changes. There is however, no study on how the transhumance systems have responded to these changes and whether the socio-economic and cultural significances of transhumance have changed.

Second, there is a change and broadening for functions from the Himalayan rangelands. Transhumance systems in mountains of Nepal evolved to utilise high elevation rangelands for subsistence livelihood. Due to variable and seasonal production of grasses across large areas, other means of land use by local people were impractical and there was no or little influence from the outside world due to inaccessibility and remoteness (Banskota 2000). Government policies, initially, were also to support livestock production in those areas; for instance, by establishing cheese factories where herders could sell milk and generate cash (Yonzon & Hunter 1991). However, other potential uses of landscapes gradually became apparent and government policies tried to accommodate multi-functionality. Some of them are tourism promotion and initiation of biodiversity conservation in the mountainous area.

Chapter 13 of Agenda 21 (the 'Mountain Agenda') of United Nations Conference on Environment and Development (1992) highlighted that the mountains can be one of the most popular tourist destinations due to its spectacular landscapes, majestic beauty, and high ecological and cultural diversity and tourism can improve the livelihood of mountain people (UNCED 1992). Following this, tourism was assumed to be a central means for sustainable economic development in some mountainous areas of Nepal (Nepal & Chipeniuk 2005). The government of Nepal started to promote tourism in different ways such as through opening trekking routes and permitting climbing in several peaks which were restricted in the past (Nepal 2000). As a result, tourism increased dramatically in some areas. Some people therefore switched their traditional business of animal rearing to tourism related business. On the one hand tourism has diversified income opportunities and improved the livelihood of people in some areas but on the other, it has brought socio-cultural and environmental problems (Nyaupane *et al.* 2014; Sharma 2000).

Conservation demands from globally significant high Himalayan ecoregion (Olson & Dinerstein 2002; Olson *et al.* 2001) also increased and countries from the Himalayan region committed to making significant contribution to global conservation (Chettri *et al.* 2008). The Government of Nepal has also responded to the global conservation movement establishing different types of protected areas (PAs) and forest management schemes. After the enactment of the *National Parks and Wildlife Conservation Act* (1973) (NPWCA), 20 PAs were established throughout the country, of which 12 are located in high hill and mountainous areas (DNPWC 2014; Shrestha *et al.* 2010).

Protected areas of Nepal are acknowledged for their role in protecting endangered and charismatic mammals, but there are concerns as they are located in territories of indigenous peoples (Stevens 2013) and removed many customary rights (Heinen & Shrestha 2006). The *Forest Act* (1993) legalized the concept of community forestry whereby patches of government managed forests are handed over to users groups for conservation, management and utilisation. Since then more than 1.6 m ha of government managed forest (about 23 % of national total forest) have been handed over to 17,685 Community Forest Users Groups (CFUGs) (DoF 2014; MFSC 2013); most of them in the mid-hills. Nepal is one of the pioneering countries for initiating community forestry (Nurse & Malla 2006) and considered successful in reviving greenery in degraded lands. However, some studies (Ahlborg & Nightingale 2012; Banjade & Paudel 2008; Gautam 2009) have also indicated that the issues of marginal people and groups are neglected by CFUGs (Gautam 2009). It is important to know how PAs and community forestry policies consider transhumance grazing, what the current practices at local level are and how they are perceived by transhumant herders. Adverse perceptions of policies and practices will be a disincentive to herding.

Third, there is no or little support from policy makers for transhumance grazing in the Himalayan region because there is a debate as to whether the grazing is beneficial or detrimental to rangeland ecology and biodiversity (Rao *et al.* 2003a; Roder *et al.* 2002). Conservation policies seem to generally assume or imply that transhumance is at least of little benefit to biodiversity conservation and ecosystem function and possibly detrimental, leading to regulatory rather than collaborative approaches to conservation (Gadgil *et al.* 1993; Rao *et al.* 2003a). Policy makers of Nepal also assume that rangelands are degraded and grazing is the main reason for such degradation (Miller 1995; Pande 2004; Pradhan *et al.* 2003), but there are no site-specific records for number of livestock and there is no scientific study about the effect of transhumance grazing in rangeland ecology and biodiversity in the Nepal Himalaya. Studies from other regions suggest that the degradation and bush encroachment could be due to other factors such as abandonment of rangelands (Baur *et al.* 2006; Palombo *et al.* 2013; Sharma *et al.* 2013) or the suppression of fire (Angassa & Oba 2008; Shaoliang *et al.* 2007; Wangchuk *et al.* 2013) rather than due to overgrazing. Furthermore, previous studies from other regions show that there is no single response of plant diversity to livestock grazing. Diversity may increase (Humphrey & Patterson 2000; Pykälä 2005; Rambo & Faeth 1999) or decrease (Landsberg *et al.* 2003; McIntyre & Lavorel 1994) with the increase in grazing intensity. The highest plant diversity at intermediate levels of grazing (Taddese *et al.* 2002) and no effect (Metzger *et al.* 2005) have also been reported. Given this uncertainty, there should be an in-depth scientific study to relate livestock grazing and rangeland plant diversity in the mountainous rangelands of Nepal, as argued in the *Nepal Environmental Policy and Action Plan* (1993) and the *Rangeland Policy* (2012) that can convey correct information to policy makers.

Fourth, climate change has emerged as a systemic threat to the transhumance system that compounds earlier socio-economic and political changes. Temperature trends suggest that warming is more pronounced in the northern high altitude areas than in the lower elevations of Nepal (NAPA 2010; Shrestha & Aryal 2011). The form of precipitation will change in the higher Himalayas where there will be more rainfall instead of snowfall. This will reduce the snow cover duration in rangelands (Paudel & Andersen 2011) which provides moisture for a long period of time. Transhumance systems are practised in those areas which are most affected by global climate change (Kullman 2004) and are likely to be affected by the timing of rainfall, agricultural seasons, persistence and melting of snow in rangelands, availability of water near grazing spots and so on. Previous studies (Gentle & Maraseni 2012; Macchi *et al.* 2014) suggest that climate change has affected the livelihood of people in the mountainous areas of Himalayas and has added to the burdens of marginalised people. The transhumant herders may be disproportionately more vulnerable due to climate change (Dong *et al.* 2011) and the situation could be even more severe when the flexibility of herders is restricted (Fu *et al.* 2012; Sherpa & Kayastha 2009; Tyler *et al.* 2007). However, there is a lack of study on how vulnerable they are to climate change, how climate change may impact transhumance systems and how climate change is perceived by transhumant herders. If herders do not recognize climate change, they are less likely to take steps to adapt.

Therefore, it is evidenced that the transhumance system in the mountains of Nepal is under pressure due to multiple factors. The decline or loss of such TSESs is often associated with adverse social-cultural and ecological impacts (Homewood 2004; Kala & Shrivastava 2004; Nautiyal & Kaechele 2007; Oteros-Rozas *et al.* 2012). However, there is no information about the current status of the transhumance system, its socio-cultural, economic and ecological roles, major changes in the system and likely impacts from such changes. Therefore, it was realized that an integrated study is essential in the northern mountainous areas of Nepal to resolve these research problems (*Rangeland Policy* 2012; Aryal *et al.* 2014). Hence, the objectives and research questions of this study were framed to address these research problems and given in the following section.

1.3. Goal, objectives and research questions

The overall goal of this study is to examine the transhumance system in the northern mountainous areas of Nepal.

The objectives and specific research questions under each objective are:

1. To investigate the contemporary transhumance systems and their socio-economic and cultural significances

i. What is the status of transhumance systems (proportion of households (HHs) practicing transhumance, herd size and composition, seasonal grazing patterns) in the study areas?

ii. *What are the socio-economic and cultural significances of transhumance systems?*

2. To determine the ecological role of transhumance grazing in the Himalayan rangelands

iii. *How transhumance grazing affects plant species richness and composition in the Himalayan rangelands of study areas?*

3. To identify the major drivers of change to the transhumance systems

iv. *What are the implications of globalisation (tourism, labour migration) to the transhumance systems?*

v. *What are the implications of state conservation policies and practices to the transhumance systems?*

vi. *What are the implications of climate change to the transhumance systems?*

4. To identify the major changes in the transhumance systems and their social-ecological impacts

vii. *What are the major changes in the transhumance systems?*

viii. *What are the likely social-ecological impacts from the changes in the transhumance systems?*

1.4. Scope and significance of the study

This study considers the transhumance system among other livestock production systems in Nepal where it is practiced in the northern mountainous region. Transhumance systems comprise both the social and ecological components and this study revolves around these components (Figure 1.1). This study takes a holistic (system thinking) approach which requires a hybrid research method that combines research tools and methods from both the social and natural sciences.

The study is significant in a number of ways; all related to the possibility that this is a system that seems to be undergoing major change and possible extinction. The socio-economic, cultural and ecological significances in the changing contexts and the social and ecological consequences from the changes or loss of systems have been little examined and there are a number of reasons for doing so. First this will help to preserve the indigenous knowledge from this system and contribute to the sustainability of the system (Fernández-Giménez & Fillat Estaque 2012).

Second, it will contribute to debates about the ecological role of transhumance grazing in the higher Himalayas. This study will increase the evidence base relating to transhumance grazing and rangeland biodiversity particularly studying patterns of species richness and composition along the distance from livestock assembly points.

Third, the study has potential to recommend adaptation measures to climate change and to inform the formulation and evaluation of state policies, plans and programmes related to rangelands, livestock and conservation. The study will also inform future evaluations of the Rangeland Policy (2012).

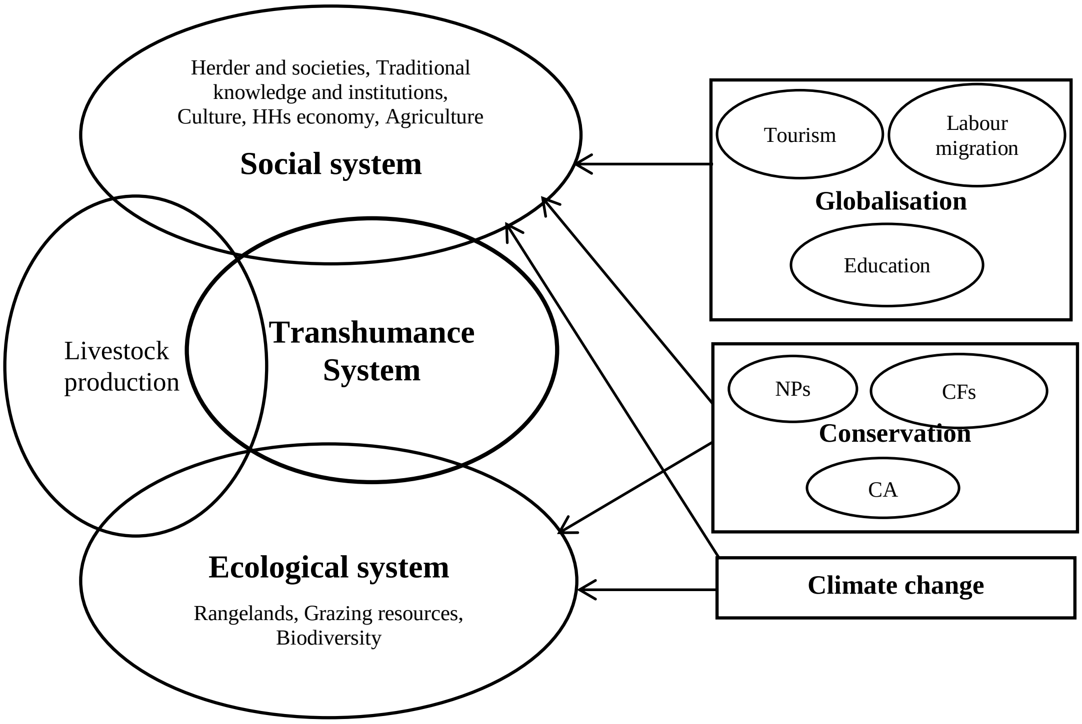

Figure 1-1: Components of transhumance system and scope of the study

Finally, the methodological approach applied for the study is novel in the sense that it combines ideas from different disciplines to investigate a socio-ecological system (SES) that has been experiencing multiple change pressures. Furthermore, there is limited knowledge about the socio-ecological impacts form the loss of traditional SES. The study of SESs is a relatively new area and within that, traditional SESs are of particular interest. But the transhumance system of the Himalayas has not been studied with this approach. This study could be an example for investigating other SESs that are constrained by contemporary threats.

1.5. Structure of the thesis

This thesis is organised into eight chapters (Figure 1.2). After this introductory chapter (chapter 1), the detailed overview of transhumance is given and dimensions of the study are illustrated (chapter 2). The description of the study areas, methods of data collection and analysis is given in chapter 3.

The findings are presented from chapter 4 to chapter 6. In Chapter 4, the current status of the transhumance system and its socio-economic and cultural significance are presented. In the ecological section, the role of transhumance grazing in rangelands in terms of its effects to plant diversity and composition are presented (chapter 5). In chapter 6, major drivers of change and major changes in transhumance systems are described.

The findings that are presented from chapter 4 to chapter 6 are discussed in chapter 7. The thesis concludes in chapter 8 which covers a brief summary of findings, research contributions and policy recommendations. Some avenues for further research are also given at the end of this chapter (chapter 8).

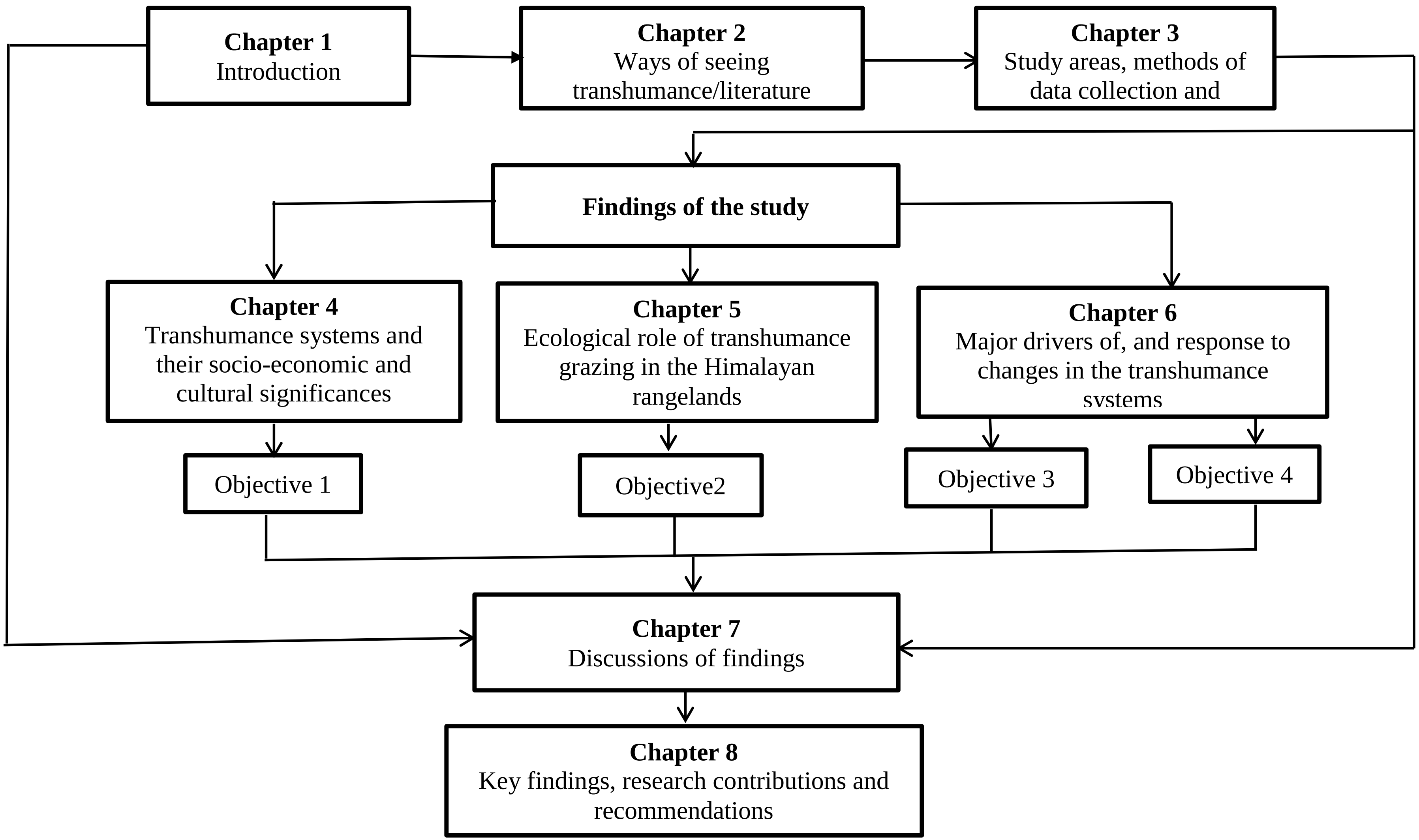

Figure 1-2: Flow diagram of chapters

1.6. Conclusions

Transhumance systems are based on the seasonal movement of livestock between fixed points. They evolved in major mountain systems of the world including the Himalayas in response to a harsh climate and low and seasonal production of grazing resources at different elevations. Traditional SESs such as transhumance systems are acknowledged for their socio-economic, cultural and ecological importance but they are increasingly open to external change factors. This change is occurring where there is little knowledge of the status of, and socio-cultural and ecological roles of the transhumance system in the mountainous region of Nepal. Considering a transhumance system as a SES, this study aims to examine the transhumance systems. This study is significant in a number of ways including the potential effect of different drivers of changes to the transhumance systems, having the potential to resolve the uncertainty about the effect of seasonal livestock grazing to the plant diversity and composition in the Himalayan rangelands, having potential for suggesting local adaptation strategies to climate change, and recommendations for formulation and evaluation of state policies, plans and programmes related to livestock, rangeland and natural resource management. The thesis is organised in eight chapters.

Chapter 2 : Ways of seeing transhumance

2.1. Introduction

First, this chapter presents an overview of transhumance, which is downscaled to the Himalayas and then to the mountainous region of Nepal. The rangelands, livestock and herders (people) are described as different components of the system and seasonal mobility, traditional knowledge and culture as key features of the transhumance systems. Second, the socio-economic, cultural and ecological importance of social-ecological system (SES), contemporary threats, changes brought about by these threats and implications from the decline or loss of such systems are given. Third, the research gaps identified in chapter 1 are elaborated and key conceptual questions are presented. Finally, a human-nature interaction is explained as a theoretical perspective, and a transhumance system is contextualised as an SES and the framework for the study has been proposed.

2.2. Overview of transhumance

2.2.1. Transhumance: A type of pastoral system

Livestock production systems differ widely in terms of resources use, degree of intensification, species and orientation (Bernués *et al.* 2011). Most frequently, these systems have been classified based on land use by livestock. According to this criteria, there are three types of livestock production systems (Devendra 2007; Sere *et al.* 1995; Steinfeld *et al.* 2006; Thornton *et al.* 2009); (i) grazing systems (pastoral systems), (ii) mixed farming systems, and (iii) industrial or landless systems.

Pastoralism is seen by some as an evolutionary stage in human history, following the hunting-gathering and prior to sedentarisation and agriculture (FAO 2001). It thereafter continued in the areas not suitable for agriculture or complementary to agriculture. Pastoralism has four categories, bases on the degree of movement; i) nomadism, ii) transhumance, iii) agro-pastoralism and iv) enclosed system and ranching (FAO 2001). Niamir-Fuller (1998) classified pastoralism into nomadism, transhumance and semi-transhumance in decreasing order of mobility. Movements of nomads are opportunistic and follow pasture resources in a pattern that varies from year to year whereas transhumance refers to the regular movement of herds between fixed points to exploit seasonal availability of pastures (Ayantunde *et al.* 2011). Agro-pastoralists are settled pastoralists who cultivate sufficient areas to feed their families from their own crop production. Agro-pastoralists hold land rights, use their own or hired labour to cultivate land and grow staples. While livestock are still valued property, their herds are on average smaller than other pastoral systems and graze within a finite area around their village which can be reached within a day. Enclosed system or ranching includes livestock production whereby the animals are kept on large but enclosed expanse.

In transhumance, livestock are moved seasonally between fixed points to utilize availability of grazing resources (FAO 2001; Fernandez-Gimenez & Le Febre 2006; Nyssen *et al.* 2009). Transhumance is often associated with the production of some crops, although primarily for herders' own use rather than for markets (Jones 2005). Transhumant pastoralists often have a permanent homestead and base at which the older members of the community remain throughout the year. Transhumance is one of the many customary practices developed by ancient Mediterranean societies to cope with an unpredictable and highly fluctuating climate (Oteros-Rozas *et al.* 2012). Common features of transhumance are flexibility, complexity and the utilization of complementarities in space (between habitats/landscapes) and time (between seasons) (Herzog *et al.* 2005). Advantages of transhumance include that there is access to better pastures and livestock enjoy a high degree of freedom which ultimately benefits the nutrient and health of livestock. However, there is additional energy expenditure for movement, the chance of irregular supplies of grazing resources and a high incidence of pests and diseases. Turner *et al.* (2014) argue, however, that the advantages of livestock mobility outweigh the disadvantages.

2.2.2. Transhumance in mountains

Mountain areas cover one fifth of the world's terrestrial surface (Körner *et al.* 2005). Mountain regions possess three major ecological and environmental features (Rhoades & Thompson 1975): (i) vertical biotic zonation; (ii) irregular biotic distribution; and (iii) geologic features of slope, elevation, and ruggedness of surface configuration. Adaptation by human or animal populations must involve strategies for coping with these features (Spoon 2013). Transhumance is one of the adaptive strategies developed by the mountain people for the optimum utilisation of low productive mountain pastures (Körner *et al.* 2005). Vertical transhumance involves livestock moving between high elevation pasture in the summer and low elevation valleys in the winter, effectively there is a vertical stratification of resources by altitude (Galaty & Johnson 1990; Montero *et al.* 2009). Transhumant herders follow a seasonal calendar to utilise these pastures. Inverse transhumance i.e. downward movement of herds in the summer, are also reported from some areas of Europe such as in County Clare of Ireland where animals are taken to the higher plateau in winter that retains the heat captured during the summer (Biber 2010). Crop cultivation is generally geographically restricted due to climatic, edaphic and topographic factors in the cold high mountain areas but transhumance links high mountain rangelands with the agricultural land in the valleys and in some cases adjacent lowlands (Herzog *et al.* 2005).

Pollen and beetle analysis showed that transhumance was practised in the high mountains near Neor of Iran at least 6500 years ago (Ponel *et al.* 2013). The pastoralism in Tibet, adjacent to Nepal, has a history of around 8800 years indicating its start during the mid-Holocene climatic optimum (Miehe *et al.* 2009). Transhumance exploiting diverse areas including lowland, middle altitude and mountain environments in Pyrenees had origins in the Mesolithic era (around 15000 years ago)

(Geddes 1983). There is a difference in pasture availability between the tropical and the temperate mountains. In tropical mountains such as in the Andes, there is year round pasture availability for grazing but for the temperate mountains like the Alps and the Himalayas, high elevation pastures are available only for the summer months (Rhoades & Thompson 1975). Therefore, in some tropical mountains such as in the central Andes, sedentary systems were well established because there is no pronounced seasonal variability in fodder availability. The shift from sedentary to migratory patterns is a response to the perception of economic opportunity (Stewart *et al.* 1976).

Pastoralism in the Hindu Kush-Himalayan (HKH) region is thousands of years old (ICIMOD 1997) and sometimes it is mentioned that pastoralism is 'as old as hills' (Chakravarty-Kaul 1998). More than 60% of the HKH region is covered by rangelands which are the source of livelihood for 25 to 30 million pastoralists and agro-pastoralists (ICIMOD 2009). Transhumant agro-pastoralism is considered as an important part of the living cultural heritage of the Himalayas (Banskota 2000; Namgay *et al.* 2013). This is still the main livelihood strategy for many families in the high Himalayas (McVeigh 2004; Moktan *et al.* 2008; Namgay *et al.* 2014). Transhumant pastoral societies inhabit the higher Himalayas and use the seasonal production of grazing areas (Bhasin 2011; Pawson & Jest 1978). As in other parts of the world, transhumance in the region is a response to harsh climatic conditions (cold temperatures), low productivity (shortage of forage) and the search for livelihood opportunities (Moktan *et al.* 2008; Namgay *et al.* 2013). Transhumant herders of the Himalayas have adjusted their livelihood activities to ecological niches at different altitudes. They use resources while synchronizing their socio-cultural activities with the seasonality of transhumant practices. Mobility during transhumance can also help diversify a pastoralists income sources through, for example, enabling the marketing/selling of livestock products and allowing other family members to work as labourers and porters (Bhasin 2011; McVeigh 2004).

2.2.3. Transhumance system in Nepal

Nepal, a small landlocked country, extends about 1000 km from east to west in the central part of the 2500 km long Himalayan mountain range. The average distance from south to north is only about 200 km. From south to the north, there are three major ecological zones in Nepal namely the Terai, the Hills and the Mountains. The Terai is a flat area in the southern part of Nepal adjacent to the middle Hill region and then further north, is the Mountain region. From Terai to the Mountains, there is a dramatic increase in the elevation and high variations in temperature, soils, vegetation, socio-economy and the livelihood activities of the local people. Agriculture is the major occupation in the Terai and Hills of Nepal but the sparsely populated mountain region has a pastoral economy based on livestock herding because crop production is limited by the cold climate and a short growing season.

Livestock production in Nepal differs through the ecological zones (FAO 2005). Three traditional livestock management system were identified and described by Pariyar (2008) in Nepal. According to him, they are the (i) transhumance; (ii) sedentary; and (iii) stall feeding. The transhumance system is predominant in the mountains, the sedentary system in the mid-Hills and the stall feeding system in the Terai and low-Hill regions (Pariyar 2008).

In Nepal, the transhumance system is common in the northern mountainous areas (FAO 2005; Pariyar 2008; Sharma 2006). Livestock move seasonally in an annual cycle according to their requirement and grazing resources availability at different altitudes. Herds of yaks, *chauri* (female crossbreed of yak/nak and cow/bull), cattle, sheep, goats and horses seasonally move from one place to another. Yaks can occupy an ecological niche in between 3000–5000 metre above sea level (m asl), *chauri* move between 1500 and 4000 m asl, while cattle move between 2000 and 3000 m asl. In contrast, sheep, goats and horses are more adaptable and move between 1200–4000 m asl. Rangelands at higher altitudes are only accessible in summer (July–September) season. Therefore herds are moved to low lying areas in the winter (December–February) season. During transhumance, livestock utilizes forage resources of alpine pastures to stubbles from fallow agricultural lands of lower elevation. During upward and downward migration, undergrowth in the forest is the major forage source. The transhumance of sheep and goats covers large altitudinal ranges between summer and winter pastures (Pawson & Jest 1978).

2.2.4. Components of transhumance system

The transhumance system has three components (Figure 2.1); rangelands (land), livestock and herders (labour or people) (Brower 1990). Livestock production primarily depends upon grass availability and the productivity of the rangelands. Rangelands include grasslands, scrublands, woodlands etc. Broadly, rangelands (grasslands) are categorised as climatically determined, successional and agricultural (Milchunas *et al.* 1988). Climatically determined rangelands occur in areas where the availability of soil water is below the requirements of trees. Savannah and shrub steppes are examples of climatically determined rangelands. Successional and agricultural grasslands result from the removal of original forest and are maintained by agronomic or other management practices.

Rangelands differ from pastures in the sense that natural vegetation grows in the rangelands whereas plants are established by human beings in pastures. Rangelands used for domestic livestock are often the common property of several owners (Crépin & Lindahl 2009) and are managed principally with extensive practices such as managed livestock grazing and prescribed fire rather than seeding, irrigating, and using fertilizers. Grazing is the predominant method of livestock feeding in the transhumance system. Therefore, the importance of rangelands is greater in transhumance systems than in other livestock production systems.

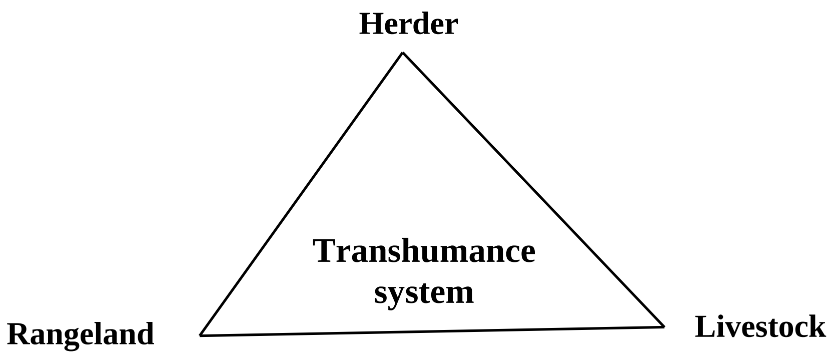

Figure 2-1: Different components of transhumance system

Rangelands cover approximately one-third of the Himalayan land area and are concentrated in higher elevation regions, usually above 3000 m asl where grasses and alpine shrubs are the dominant vegetation (McVeigh 2004; Miller 1995). In Nepal, rangelands occupy almost 12 percent of the land mass of the country and an additional 10% by scrublands which are also used to graze livestock (LRMP 1986). About 80 % of the grazing land lies in the high mountains and higher Himalayas and about 27% lies within protected areas (*Nepal Biodiversity Strategy* 2002; *Rangeland Policy* 2012). The rangelands in Himalayas, including the mountainous areas of Nepal, also represent one of most significant global 200 ecoregions, the 'alpine shrub and meadow' ecoregion (Basnet 2003) and a biodiversity hotspot, the 'Indo-Burma' (Brooks *et al.* 2006a; Myers *et al.* 2000).

The average forage productivity of the natural rangeland varies depending upon the location, altitude and the edaphic environments. Furthermore, the inter-annual precipitation variability strongly influences vegetation production in the rangelands (Paudel & Andersen 2010). The scattered grazing resources in the rangelands are converted through livestock to different products that are consumable by human beings. The rangelands vegetation at high altitude is fragile and susceptible even to the low intensity disturbance. The rangelands have historically been a major source of livestock rearing in Nepal for many generations. Different types of livestock are reared for different purposes and the purpose of rearing livestock also varies from place to place. This is also influenced by the culture of the local people. For example, in Hindu culture, the consumption of beef is prohibited and cows are mainly reared for dairy products whereas in other cultures, they serve as the primary meat item.

Livestock rearing is an important livelihood activity in Nepal. From national figures, 3 out of 4 households own livestock and Nepal has the highest ratio of livestock to humans in Asia (IRIN 2013). Virtually every household in the mountains and in the hilly areas owns livestock. About 95% of households in the mountains own large ruminants (Maltsoglou & Taniguchi 2004). Agriculture sectors have contributed 37.6% of total gross domestic product (GDP) of which one third is contributed by livestock (FAO 2005). Despite its importance, livestock production is declining in

Nepal (IRIN 2013). The trends for number of livestock in Nepal differ with different sources. According to the statistics published by Ministry of Agricultural Development, there is an increasing trend for all livestock types except sheep from 2000/01 to 2012/2013 (Table 2.1). However, the statistics from Central Bureau of Statistics (CBS) Nepal published from agricultural census shows declining trends for cattle, *chauri*, buffaloes and increasing trends for goat and pig from 2001/02 to 2011/12 (Figure 2.2).

Table 2-1: Livestock types and their number in Nepal

SN	Livestock type	Numbers (in, 000) 2000/01	Numbers (in, 000) 2012/13
1	Cattle	6982.66	7274.02
2	Buffaloes	3624.02	5241.87
3	Sheep	850.17	809.53
4	Goat	6478.38	9786.35
5	Pigs	912.53	1160.03
6	Milking cow	852.58	1025.59
7	Milking buffaloes	936.81	1369.79

Source: Ministry of Agriculture and Co-operatives (2013)

Herder's traditional knowledge on plant-animal-environment relationship is important in pastoral livestock production (Fernandez-Gimenez 2000; McVeigh 2004). Livestock herders have historically played a key role in developing and sustaining the rangelands of the greater Himalayas (Dong *et al.* 2007; McVeigh 2004). In Nepal, there are some ethnic communities; *Sherpa*, *Tamang*, *Gurungs*, *Bhotia* and *Dolpo* who are well known for historical adoption of transhumance practice. These communities mostly inhabit rugged terrain of mountains and follow the movement of livestock including cattle, yaks, sheep and goats. They develop and practice various herd and rangeland management strategies such as moving herds to adjust grass availability in different agro-ecological zones and dividing pastures among herders to avoid overgrazing.

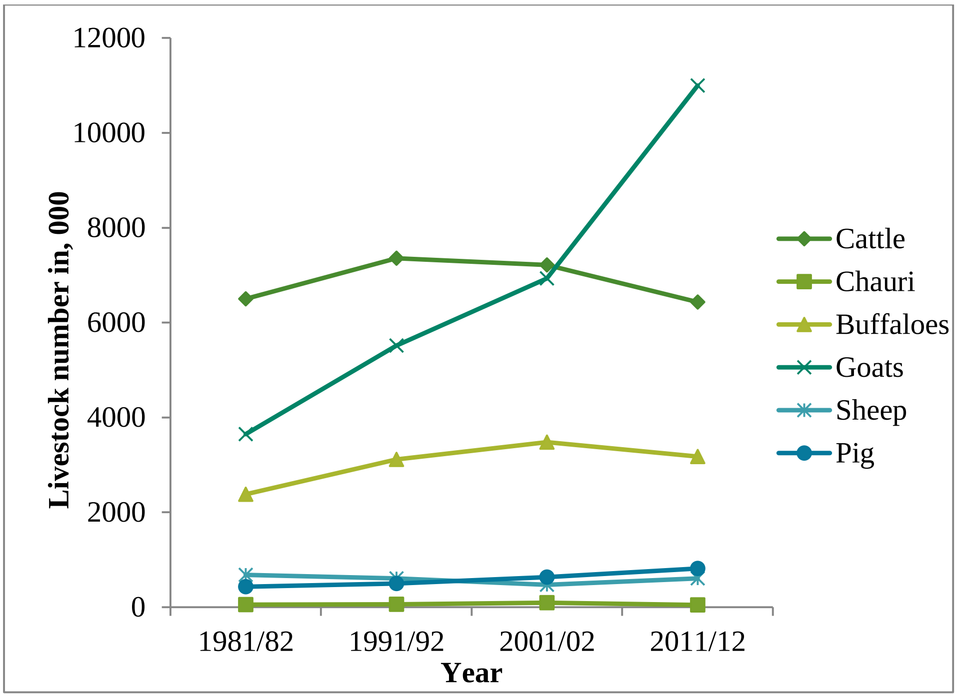

Figure 2-2: Trends of different livestock types in Nepal; **Sources:** CBS (2006) and CBS (2014))

2.2.5. Understanding mobility in transhumance

Mobility of livestock can be viewed based on two knowledge systems. In terms of local knowledge systems or from a herder's perspective, it is rational to move livestock to the area with available grazing resources (Adriansen 2006). Livestock mobility is both an economic and ecological necessity and an adaptive response of herders as grazing resources are distributed over larger spatial areas. When grazing resources are distributed over a large area and productivity is low, it is uneconomical to use those lands for another purpose. Mobility offers more flexible and adaptive utilisation of resources (Fernandez-Gimenez & Le Febre 2006; McAllister *et al.* 2006; Wang *et al.* 2014) and helps to convert low quality plant resources into high quality animal products. Transhumance helps to achieve multiple objectives of the practitioners (Bell & Moore 2012; Bishop 1989; Wright *et al.* 2012). From the scientific knowledge system, the mobility is ecologically rational in arid and semi-arid ecosystems to avoid overgrazing and rangeland degradation (Adriansen 2006). It provides vegetation in grazed areas a recovery period (Bruegger *et al.* 2014). Furthermore, the mobility is the best way to deal with environmental variability such as drought and resource variability (Dong *et al.* 2009a; Moktan *et al.* 2008; Nyong *et al.* 2007).

2.2.6. Transhumance system, indigenous knowledge and culture

Indigenous knowledge is a cumulative body of knowledge, practice and belief built by a group of people in close contact with nature and handed down through generations (Berkes & Berkes 2009). Indigenous knowledge pursues holism by considering large number of variables (Berkes & Berkes 2009). Generally, people living in agrarian societies and remote areas following a livelihood based on direct utilisation of natural resources, are considered rich in indigenous knowledge (Lebel 2013; Rao *et al.* 2003b). Even within the same geographical areas and communities, traditional knowledge and their use can differ based on age, gender and ethnicity (Ayantunde *et al.* 2008; Oladele 2012). They gain knowledge based on experiences and social interactions. Pastoralists who follow grazing based livestock production combine experiences and knowledge gained by trial and error, and develope certain sets of rules and regulations for resource utilisation. They possess active knowledge applied to management decisions, embedded knowledge from living in the place and integrative knowledge linking ecological, social and economic aspects (Knapp & Fernandez-Gimenez 2009).

There are literatures from around the world indicating that the knowledge of herders can be instrumental for different purposes. Studies have shown that such knowledge is useful in assessing rangeland conditions (Dong *et al.* 2009a), rangeland biodiversity (Waudby *et al.* 2012), plant palatability (Waudby *et al.* 2013), landscape condition (Oba & Kaitira 2006; Spoon 2011) and ecosystems dynamics (Kgosikoma *et al.* 2012). Furthermore, they are used in managing grazing (Mapinduzi *et al.* 2003) and rangelands (Dong *et al.* 2010; Fernández-Giménez & Fillat Estaque 2012). The indigenous ecological knowledge of the transhumant herders is sometimes even seen as superior to that of modern ecologists in relation to grazing management (Oba 2001). Indigenous ecological knowledge for assessing grazing pressure (based on plant utilisation, density of faecal drops and density of livestock track) and rangeland degradation (based on indicator species) can be considerable (Bruegger *et al.* 2014; Oba & Kaitira 2006).

In addition to the indigenous knowledge, the transhumance system is closely associated with the culture of many societies. Transhumance itself is sometimes seen as one step of human civilisation following hunter-gatherers and before sedentary agriculture. The transhumance system has also been described as a living cultural heritage (McVeigh 2004; Namgay *et al.* 2013) and social ideology (Chang 1993). Oteros-Rozas *et al.* (2012) and Oteros-Rozas *et al.* (2014) have described 12 cultural services of transhumance. The transhumance between upland and lowland in the mountainous areas are sometime compared with natural activity such as seasonal migration of birds (Chang 1993). The movement is also described as a period of joy and expectation such as to leave the heat of the plains for cool mountains, an opportunity for leisure time and less expense for livestock production (Gooch 2009). Some livestock and their number symbolise the social status of the households in rural societies (Subedi 2007).

Though transhumance is a historically evolved livestock production system in the Higher Himalayas, there is little information about the traditional knowledge and socio-cultural aspects of transhumant herders in the Himalayan region. Farooquee *et al.* (2004) documented indigenous knowledge of a transhumant *Bhotiya* community of central Himalayas and found that a number of wild plants are domesticated and developed their own mechanism for cattle production. In a case study from Rasuwa District in northern Nepal, Dong *et al.* (2007) concluded that local herders had developed an indigenous rangeland management system because herders have traditionally classified rangelands based on livestock suitability and practice rotational grazing based on feed availability. To fulfil the knowledge gap on indigenous knowledge, culture and traditions related to the transhumance systems, this study attempts to document traditional knowledge, beliefs and practices associated with transhumance systems in the study areas.

2.3. Transhumance system: Status and trends

2.3.1. Transhumance system: A declining practice

Examples from around the world indicate that the transhumance system has been declining, contracting or transforming. There is a marked decline of transhumance systems in Mediterranean Spain (Oteros-Rozas *et al.* 2013a) and Romania (Juler 2014). Tibetan sheep population under transhumance has declined in Sikkim, India as younger generations are attracted towards alternate sources of income (Banerjee 2009). Transhumance and customary lifestyle has been changed in Kumaon Himalaya (lies in Uttarakhand State of India) due to the separation of trade with Tibet (Negi 2007). Indigenous knowledge and practices of transhumant *Bhotiya* communities are on the verge of extinction due to the integration of this society with the mainstream of other societies and the market economy (Farooquee *et al.* 2004).

Some long distance movements are gradually replaced by short distance movements, for example in Romania (Huband *et al.* 2010). In West Africa, long distance movements are inhibited by different climatic, socio-political and land use changes (Gonin & Gautier 2015; Turner *et al.* 2014). Availability of alternative livelihood options and change in policies and climate have been affecting this system in Bhutan (Namgay *et al.* 2013).

The dependency on livestock base has been reduced in many pastoral systems (Ayantunde *et al.* 2011; Shaoliang *et al.* 2008). Traditionally, mountain nomads of Karakoram were engaged only in very few side activities beyond animal husbandry but this tradition has changed quite drastically and they have diversified their activities in recent years (Kreutzmann 2004). In some areas, such as in Yunnan, China, fewer households (HHs) graze on the alpine meadows than in the past which has increased grazing pressure in low altitude rangelands (Wilkes 2006) as well as the number of days on stall feeding (Shaoliang *et al.* 2007). Both decrease in grazing in alpine areas and overgrazing in low altitude might have ecological implications.

2.3.2. Reasons for declining transhumance system

Pastoral systems are vulnerable and it is uncertain whether or not pastoral systems and societies will continue in the future (Mearns 2004). Similar to other traditional social-ecological systems (TSESs), there is tremendous pressure from contemporary changes to the transhumance system (Farooquee 1998). Both aspects of globalisation; the global social change as well the global climate change have affected the transhumance system. The term globalisation has different meaning in different disciplines, therefore, it is very difficult to define and trace indicators of globalisation that fits all disciplines. However, the common interpretations of globalisation are the idea that the world is becoming more open and homogenous through a technological, commercial, and cultural synchronization (Pieterse 1994). Globalisation has increased the flow of people, ideas, knowledge, technology and money by various degrees (Young *et al.* 2006) and has brought people from distant parts closer. The global social changes include the widening, intensifying, speeding up and growing impact of world-wide connectedness. The economic and cultural attractions of urban life has played an important role for rural-urban migration, particularly for young people (Aide & Grau 2004). Shortage of family labour, increased workloads and change in social and cultural values were identified as the major three risks of transhumance systems in the Swiss mountains (Jurt *et al.* 2015). Young *et al*. (2006) also argued that globalisation is now a central feature of human-environment systems.

There are the social and economic changes in some communities which are mostly driven by globalisation. But the impacts of the globalisation are too uncertain in remote mountainous areas (Chaudhary *et al.* 2007). The Himalayan transhumance system is affected by both emigration and immigration. About 15 % of the world's migrants come from the countries of the HKH region (Hoermann & Kollmair 2009). The migration of young people from Himalayan countries was induced by labour demand in other countries that has created a shortage of people in livestock rearing. Although the migration is not a new phenomenon, globalisation has boosted it to unforseen levels. Migration from Nepal has tripled since the 1980s (Hoermann & Kollmair 2009). Overseas migrants from the Himalayan countries are largely attracted by employment opportunities in the Gulf countries as their booming construction sector offers vast employment opportunities for unskilled workers. The rural-urban and international migration induced by globalisation might have implications to the local ecosystems as seen in the Latin America (Aide & Grau 2004).

In addition, with the increased number of tourists, there was a flow of information and culture. Tourism also creates alternate employment opportunities attracting local people towards tourism business. The economic transformation from traditional farming and animal husbandry to tourism has been accomplished in some areas near trekking routes (Fisher 1990). Tourism has also opened ways to tourists who rarely possesses ecological or cultural knowledge (Forbes *et al.* 2009). In Nepal, the school enrolment of children has increased in all parts of the country and many HHs (especially from the tourism dominated sites) have sent their children to district headquarters and other cities. All of these processes have reduced the involvement of younger generation in the transhumance system.

The regional tension and disruptions of trade across the Tran-Himalayan border with Tibet was another reason for the decline of transhumance systems in the Himalayan region (Bauer 2004; Bhasin 2011). The export of livestock products from higher Himalayas and the import of salt from Tibet was an integral aspect of the transhumance system. The movement of livestock across the border was important because livestock from higher Himalayas were used to graze in Tibetan rangelands. The movement across borders was also important as it would help gene flow and reduce the chance of inbreeding. However, access restriction to summer pastures and trade with Tibet has disturbed the traditional base of local economies (Brower 1992; Rose & Scholz 1980).

Another factor affecting transhumance systems is the introduction of conservation and forest management policies. The establishment of protected areas (PAs) in Bhutan and Nepal has restricted resource appropriation by herders (Seeland 2000). The change (decline) in the transhumance in the Nanda Devi Biosphere Reserve was attributed to different factors: disruption of trade with Tibet, improved access and service, increased tourism and employment opportunities, and increasing constraints to transhumant pastoralism from conservation (Nautiyal *et al.* 2003). Therefore, a better understanding of the current transhumance system and how it is changing and responding to the recent changes is critically important.

2.4. Livestock grazing and plant diversity

One of the objectives of the study is to explore the ecological role of livestock grazing in the Himalayan rangelands in order to contribute to debate as to whether grazing is beneficial or detrimental to biodiversity and to infer likely ecological impacts if transhumance grazing is lost for any reasons. This section first presents the theoretical understanding for how grazing affects plant diversity in the rangelands. Second, a brief synopsis of different methods used to study the effect of livestock grazing to plant diversity and findings of previous studies are given. An indication of approach and methods to be followed by this study is given at the end.

2.4.1. Grazing and plant diversity in rangelands: Theoretical underpinnings

Grazing is an important ecological factor in rangelands. Olff and Ritchie (1998) mentioned that local colonization and local extinction are two major processes determining local plant species richness in grasslands. Herbivores have potential to affect those processes in different ways including the removal of seeds, soil fertility and preferential grazing. Three mechanisms by which grazing animals alter biodiversity are: selective defoliation altering competitive advantage between plant species, treading that opens regeneration niches for gap-colonizing species and nutrient cycling (Rook *et al.* 2004).

The effect of herbivores on plant species richness depends upon types and abundance of herbivore, scales (temporal and spatial) at which diversity is measured and environmental gradients. Spatial variability occurs at landscape and patch levels (Landsberg *et al.* 2002) because grazing pressure is not uniformly distributed throughout the landscape. This is especially true in areas with free-range grazing. Grazing activities are related to the distribution of the grazing resources (food), water and minerals (Adler *et al.* 2001). At the local scale, grazing animal effect varies with vegetation types, accessibility of patches, area protected by obstacles such as shrub.

Pastoral systems in rangelands are also viewed in terms of equilibrium and non-equilibrium concepts. Equilibrium ecosystems occur in the areas where climatic variability is not very high and livestock grazing is the major factor affecting vegetation. Arid and semi-arid range ecosystems function as non-equilibria systems where plant growth and rangeland productivity are found to be more a function of climate than livestock (ICIMOD 1997). Huston (1979) assumed that most communities exist in a state of non-equilibrium where equilibrium is prevented by periodic population reductions and environmental fluctuations. When such equilibrium is prevented, a dynamic balance may be established between the rate of displacement and the frequency of population reduction.

Different theories and models have been proposed to explain the response of plant diversity to grazing. The predation hypothesis (Paine 1966) suggest that prey diversity increases when predators prevent dominant species from monopolizing the resources. The hypothesis is mainly studied and discussed for animal prey. However, it can be applicable in rangelands assuming the grasses as prey and herbivores as predators. Livestock is a keystone species in rangelands because it influences ecosystem states by suppressing dominant species, allowing others to flourish, and preventing the succession of grasslands (van Oudenhoven *et al.* 2011).

The intermediate disturbance hypothesis (Connell 1978; Grime 1973; Horn 1975) suggests that diversity is highest at intermediate disturbance. This hypothesis proposed that too little disturbance leads to low diversity through competitive exclusion, and too much disturbance eliminates species incapable of rapid re-colonization. Disturbance prevents competitively dominant species from excluding other species from the community and there is a trade-off between species' ability to compete and their ability to tolerate disturbance. If disturbances are too rare, the competitive dominants will eliminate other species and reduce diversity and if disturbances are too frequent, most species will become locally extinct because they cannot tolerate repeated disturbances. The intermediate disturbance hypothesis is the most frequently suggested non-equilibrium explanation for the maintenance of species diversity from coexistence mechanism (Connell 1978; Roxburgh *et al.* 2004). Landscape condition might affect diversity-disturbance relationships that may cause inconsistencies in the relationship in rangeland ecosystems (Sasaki *et al.* 2009).

Long-term human land-use such as pastoralism helps to maintain rangeland ecology (Urgenson *et al.* 2014). Plant diversity to livestock grazing is based on the history of grazing and moisture gradient (Huston 1979; Milchunas *et al.* 1988), and soil fertility gradient (Olff & Ritchie 1998). Milchunas *et al.* (1988) proposed different models (Figure 2.3) showing how the history of grazing interacts with moisture gradient to alter responses of diversity to grazing.

However, it is difficult to predict which model can be applicable in the Himalayan rangelands. This is because it is not clear how to define the evolutionary history of grazing (long and short) in the proposed models and there is a lack of precise data for how long the grazing has been practiced in those areas. Furthermore, there is a considerable variation in precipitation across the region whereby some areas might be in semi-arid and others in humid. The frequent natural disasters such as snow storm, avalanches, landslides and drought might also periodically fluctuate the density of livestock in the region preventing equilibrium in the rangelands ecosystms of the Himalayas.

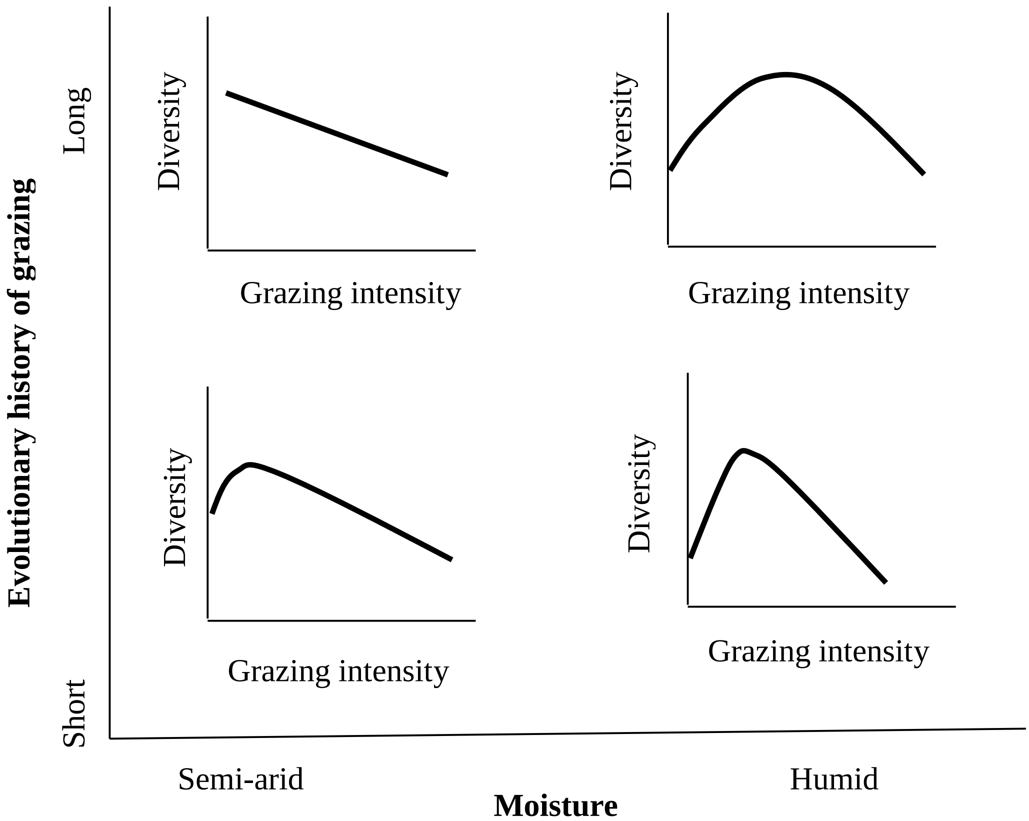

Figure 2-3: Plant diversity in relation to grazing intensity along moisture gradient and evolutionary history of grazing; **Source:** Milchunas *et al.* (1988)

2.4.2. Studying plant diversity in relation to grazing: Methods and findings

The effects of grazing on plant diversity and composition are studied through different approaches. The first and common approach is to compare the plant species diversity in the grazed and controlled sites (Metzger *et al.* 2005). The second approach is to develop grazing treatments and study of plants in treatment sites (Humphrey & Patterson 2000). The third approach is to sample plant species along the distance from livestock assembly points (Landsberg *et al.* 2003; Stumpp *et al.* 2005; Todd 2006). The last approach assumes that the grazing disturbance gradient is developed from areas with high livestock activity to areas with low activity. Trampling and compaction of the soil, as well as grazing of selected plants lead to a decrease in species richness and elimination of the most palatable species near the assembly points (Brooks, *et al.* 2006b; Landsberg *et al.* 2003; Preston *et al.* 2003). Grazing disturbance gradients and the associated floristic responses have been studied from artificial watering points (Nangula & Oba 2004; Sternberg 2012; Stumpp *et al.* 2005; Todd 2006), stock posts (Riginos & Hoffman 2003), roadside-paddocks (Fensham *et al.* 1999), mountain summer farms (Vandvik & Birks 2002b), huts (Haynes *et al.* 2013) and settlements (Preston *et al.* 2003).

Variation was not limited to the predicted response of plant species diversity to grazing (as discussed above) and methods of study, but it is also seen in the actual response of plant diversity to grazing as suggested by previous scholars. There are substantial amounts of literature reporting increases in plant diversity (Bokdam & Gleichman 2000; Pykälä 2005; Rambo & Faeth 1999) or decreases (Hendricks *et al.* 2005; Landsberg *et al.* 2003; Moustafa 2001; Todd 2006) with the increase in the grazing intensity. Some studies (Reitalu *et al.* 2010; Taddese *et al.* 2002) also report the highest plant diversity at intermediate levels of grazing. Furthermore, there are literatures indicating no effect of grazing on plant diversity (Hiernaux 1998; Humphrey & Patterson 2000; Metzger *et al.* 2005; Stumpp *et al.* 2005).

There is no study on how this seasonal grazing affects plant species richness and composition in the high Himalayan rangelands. The ecological role of grazing in the rangelands, particularly how it affects plant species richness and composition, is an important issue for rangelands management and biodiversity conservation. The conservation initiations often consider livestock grazing as a major threat. However, there are a growing number of studies reporting that the removal of traditional land use practices in the semi-natural landscape might result in adverse ecological consequences. Therefore, this study, in its ecological dimensions, aims to examine the effect of transhumance grazing to the plant biodiversity in the rangelands, studying vegetation pattern (species richness and composition) across the disturbance gradient from *goth* (semi-permanent camping and stopping spots) to the surroundings.

2.5. Community forests, protected areas and transhumance system

This section covers implications of conservation to the local resource users in general and community forestry and protected areas (PAs) of Nepal to the transhumant herders in particular. First, this section presents brief overview of community forestry and PAs in global conservation and implications to local resource users. Second, I present how studies on perceptions and attitudes of local people towards conservation measures are important and what factors affect perceptions and attitudes. Finally, I briefly describe Community Forest (CF), Conservation Area (CA) and National Park (NP) in Nepal and put forward some reasons for how this study (perception and attitude of transhumant herders) towards different schemes of forest management and conservation is needed and is interesting indeed.

2.5.1. Community forests and protected areas in global conservation movement

Several forest management and conservation models exist throughout the world. At the global level, the management responsibilities for 11% of forests remains with the communities which accounts for 22% in developing countries (FAO 2010). It is expected that the share of community forestry will reach 45% of the developing states in 2015 (Nurse & Malla 2006). In response to the widespread decline of forest supplies and the consequent negative impact on rural livelihoods, there have been self-initiated local actions to stabilise or increase the supply of forest products in developing countries. This paralleled with the changes in the approach of the forest management from central governments to local communities.

There were three main global forces for shaping tenure reforms: demand for indigenous people's rights, democratic decentralisation and conservation interests (Larson *et al.* 2010). Countries such as South Korea, Philippines, Nepal and India, where there was realisation that the centralised government failed to conserve forests, were among the pioneer countries to implement community forestry (Arnold 2001; Nurse & Malla 2006). Though the name differs from country to country such as community forestry in Nepal, Vietnam and Cambodia, social forestry in Bhutan, village forestry in Lao PDR and joint forest management in India, it involves the governance and management of forest resources by communities (Maraseni *et al.* 2005; Nurse & Malla 2006). Community forestry is central to the forest management in some countries whereas it is still in the initial stage for introduction and development in others.

Conservation through the creation of PAs is central to conservation policy worldwide (Wells & McShane 2004). The proportion of areas under protection is generally viewed as the indicator of states' commitment and efforts toward environmental conservation and, therefore, states promote the establishment and development of PAs. Therefore, the gazetted area under PAs has mushroomed in recent years. Currently, PAs cover about 15% of the global terrestrial areas. There is a great variation between PAs in size, age, purpose, designation, governance, management and outcomes (Dudley *et al.* 2010). The International Union for Conservation of Nature's (IUCN's) PA category system represents and systematizes this variation based on management objectives. This system classifies PAs from strict nature nature reserve (category Ia) where human visitation, use and impacts are strictly controlled to the PAs with sustainable use of natural resources (category VI) where low-level non-industrial use of natural resources compatible with nature conservaiton is allowed.

PAs were developed to protect iconic wildlife and landscape, but now, they are expected to achieve diverse sets of conservation, social and economic objectives (Watson *et al.* 2014). Recently, international laws on conservation have recognised the rights of indigenous people and new conservation policies accept that indigenous people may own and manage forests and PAs. However, developing countries are facing more problems in implementing top down models of PAs and forest management (Brechin *et al.* 2002; Rasaily & Ting 2012; Rastogi *et al.* 2012; Wells & McShane 2004) and conflicts with local people are widespread.

2.5.2. Implications of conservation to traditional land/resource users

It is often seen as difficult to balance biodiversity conservation and human well-beings (Adams & Hutton 2007; Aziz *et al.* 2013; Morrison 2015; Sarkar & Montoya 2011). Generally, disagreements arise when the newly introduced conservation policies focus on the number of protected species and neglect the livelihood concerns of local people, with conventional conservation policies neglecting social-ecological factors seen as the expression of short-sighted understandings (Kizos 2014) and the removal of customary rights (Colchester 2004). The local people and traditional systems which are sensitive to such policy changes (Marshall & Marshall 2007) are affected by new policies or changes to existing policies.

Conservation programmes often blame pastoral groups for environmental degradation (Gilbert 2013) and grazing restriction is a common conservation policy throughout the world (Lewis 2003). Grazing related issues are often seen as major management concerns in the mountain PAs of HKH region (ICIMOD 1997). Most of the conservation policies implemented in the region were derived from the ecological theories from northern temperate environments and have ignored the multipurpose goal of the traditional pastoral system (Rohde *et al.* 2006). These policies have assumed that traditional practices are detrimental to the conservation of biodiversity and ecosystem functions (Gadgil *et al.* 1993; Nautiyal 2011; Rao *et al.* 2003b). These national policies and development interventions have resulted in conflicts between traditional grazing and formal conservation (Kamara *et al.* 2004). Some of these policies have not only discouraged transhumant herders but also forced them to leave the traditional livestock production.

The ban on pastoral practices in the Valley of Flowers National Park in western Himalayas of India immediately resulted in conflicts between pastoralists and PA management (Kala & Shrivastava 2004) which adversely affected the vegetation dynamics of the alpine pastures (Nautiyal & Kaechele 2007). Changes in the government policies in Nanda Devi Biosphere Reserve has affected the lifestyle of the transhumant pastoralist (Nautiyal *et al.* 2003). Local people are not pleased with the benefits obtained from the park and reserve management being at the cost of traditional livelihood opportunities (Maikhuri *et al.* 2001). The trend towards the globalisation and commercialisation and/or creation of PAs have created problems for the pastoralists (Bhasin 2011). There are some cases where herder communities have used political influence to safeguard their traditional rights over bureaucratic decisions of establishing protected areas and excluding grazing (Saberwal 1996).

2.5.3. Perceptions and attitude of land/resource users towards conservation

It is important to gain insights into conservation and local people relationships. Perceptions and attitudes of local people help to understand the nature of the relationship between conservation and local people. Although it is difficult to achieve a win-win scenario where both natural resources are conserved and human-well-being is promoted (Aziz *et al.* 2013; McShane *et al.* 2011; Sarkar & Montoya 2011), a better understanding of conservation and people relationships help to improve ability to maximize benefits or at least minimise cost to local people (Basnet 1992; Holmes 2013; Morrison 2015).

It is argued that generally positive perceptions and attitudes of local people increase support and participation in forest management and conservation (Andrade & Rhodes 2012; Aziz *et al.* 2013; Badola *et al.* 2012; Borrini-Feyerabend *et al.* 2002; Holmes 2013) whereas negative perceptions and attitudes of local people are counterproductive (Brechin *et al.* 2002; Waylen *et al.* 2010). The ‘principle of local support’ (Brockington 2003) suggests that little or no opposition from local people is desirable for the successes of PAs (Borrini-Feyerabend *et al.* 2002; Holmes 2013). However, there are some contrary arguments too. For example, Bruner *et al.* (2001), Holmes (2013), and Brockington (2003) argue that the attitude of the local people plays a minor role as compared to the strict laws and enforcement mechanism that exist in PAs. There are substantial barriers which prevent local people from challenging unwanted conservation policies (Holmes 2013). Nonetheless, where knowledge of a social-ecological system is limited, there is a good case for also checking perceptions and attitudes in relation to land use practices and rules.

Understanding underlying factors can contribute even more than just identifying the nature and degree of relationships between local people and conservation. Some of the factors affecting perceptions and attitudes, as revealed by previous studies, are the level of dependency on the natural resources from PAs (Allendorf 2007; Arjunan *et al.* 2006; Xu *et al.* 2006), perception of conservation benefits (Allendorf *et al.* 2006; Ormsby & Kaplin 2005), economic condition of the household (Badola *et al.* 2012), knowledge and education of the local people (Fialloa & Jacobsona 1995; Xu *et al.* 2006), relations with PA staff (Fialloa & Jacobsona 1995; Karanth & Nepal 2012) and damage caused by wildlife (De Boer & Baquete 1998) among others. Furthermore, the attitude of the local people is related to the flexibility of the management model and involvement of local people (Vodouhê *et al.* 2010). Therefore, it can be inferred that perceptions and attitudes towards conservation are shaped by individual and location specific factors, and socio-economic characteristics.

2.5.4. A brief scenario of Community forests (CFs), Conservation Areas (CAs) and National Parks (NPs) in Nepal

The Government of Nepal has executed different forest management and conservation schemes. Community Forest (CF) is not a type of PA by Nepal's law but it is a type of forest management where a designated area is handed over to the community people (known as Community Forest User Group-CFUG) for protection, management and utilisation (*Forest Act* 1993). Nepal is one of the pioneering countries to introduce CF (Nurse & Malla 2006) and CF represents a new paradigm of forest management in Nepal (Lachapelle *et al.* 2004). The precursors of the community forestry legislation were the Panchayat Forest Rules of 1978 and Community Forestry Program of 1980 (Agrawal & Ostrom 2001). CF has been evolving as a primary means of forest management in Nepal (Agrawal & Ostrom 2001) where a total of 1,652,654 hectares of National forest have been handed over as CF to 17,685 CFUGs throughout the country (DoF 2014). The size of the CF ranges from less than 1 ha to more than 1600 ha.

CF was introduced to solve the problem of environmental degradation and to improve livelihood of forest dependent communities. The reform in tenure regime involved new restrictions and some of the practices of traditional resource users are constrained by CFs (Larson *et al.* 2010). The most common restrictions include those on grazing, logging and collection of fuel wood and fodder (Banjade & Paudel 2008; Larson *et al.* 2010). Some of the groups whose traditional practices got affected are blacksmiths who would get free charcoal from the forest, caravan trade and transhumant herders (Adhikari *et al.* 2004; Gautam 2009; Saxer 2013). There are some cases where few people (local elites) who really don't work in a forest, dominate CF and those whose everyday activities are based on forest are ignored (Ahlborg & Nightingale 2012).

Nepal has instituted progressive conservation since the 1970s and different models of conservation are in practice (Baral & Heinen 2007a; Heinen & Shrestha 2006). The legal basis to establish parks and reserves was the *National Parks and Wildlife Conservation Act* (1973). Different types of PAs; National Park (NP), Wildlife Reserves, Conservation Area (CA), Hunting Reserves, Buffer Zone (BZ) currently exist in Nepal. There are 10 NPs (IUCN category-II), 3 Wildlife Reserves, 1 Hunting Reserve, 6 CAs (IUCN category-IV) and 12 BZs covering 23.23% of the total area of the country (DNPWC 2014). National Parks (NP) and Wildlife Reserves represent the 'fortress-and-fine' model which are patrolled by military where there is greater restriction for resource use and less involvement of people's participation (Baral & Heinen 2007a). The CAs and BZs were later introduced with the amendment in the Act within the participatory conservation domain (Budhathoki 2004; Heinen & Mehta 1999; Heinen & Mehta 2000). Nepal's conservation efforts through PAs are acknowledged for reviving populations of endangered wildlife. However, they are also criticised for removing customary rights of resource users (Mehta & Heinen 2001; Stevens 2013).

2.5.5. Previous studies on perceptions and attitude of local people towards CF, CAs and NPs in Nepal

There are a numbers of studies about the perceptions and attitudes of local people towards the different types of conservation initiations in Nepal. Most of the studies have focused on PAs; mainly NPs (Allendorf 2007; Baral & Heinen 2007a), Wildlife Reserves (Baral & Heinen 2007a; Shrestha & Alavalapati 2006) and CAs (Mehta & Heinen 2001; Mehta & Kellert 1998). Past studies showed mixed results: some report that positive attitudes of local people exist (Karanth & Nepal 2012) whereas others report negative perceptions and attitudes of local people (Mehta & Kellert 1998) towards conservation.

Some studies have also explored local people's participation in conservation and factors affecting people's participation. Variables such as gender, education, household affluence and conservation attitude were predictors of participation whereas family size, ethnicity and resource dependency were not in two PAs in Western Nepal (Baral & Heinen 2007b). Even within the same PA (i.e. Annapurna Conservation Area in West Nepal), the motivating factors and barriers for participation differed in tourist and non-tourist villages (Khadka & Nepal 2010). Households having a larger family size, less land and more livestock were more likely to participate in forest protection activities in CFs of Kaski District (Chhetri *et al.* 2013). However, Shrestha (1987) found that women from the household owning larger farms were less likely to participate, while those having greater demand for fuelwood were more likely to participate. The age, sex and household income also affect participation in CF management (Maskey *et al.* 2003).

In Nepal, there are many indigenous people whose livelihoods depend upon the utilisation of the forest and rangeland resources. In the areas where transhumance systems were practiced, many PAs are established. Furthermore, large numbers of CFs were handed over in mid Hill where herders would graze in the winter season. Restrictions, rules and regulations are supplementary burdens for the people who are living a marginal life with many discomforts (Seeland 2000). Transhumant herders are among those who have been affected by the increasing demand of conservation outcomes from the areas where transhumance was common.

Although there are some studies that have explored the attitudes of local people towards PAs in Nepal, there is no comparative study that examines attitude, expectation and participation of indigenous communities towards different schemes of conservation and forest management. Previous studies have not acknowledged the heterogeneity among local people residing near PAs and treated all local people as a population of the study. However, local communities are not homogenous, the dependency of local people upon the natural resources within the community is not the same, they are not equally affected by the restriction on resource use and there is no single relationship between any PA and its neighbouring communities. Rather, multiple, coexisting relationships with different groups can occur within these populations (Holmes 2013; Kellert *et al.* 2000). Transhumant herders in the mountains of Nepal offer a good example to study the perception and attitude of local people whose livelihood chiefly depends on direct exploitation of natural resources. Therefore, this study explores attitudes, expectations and participation of transhumant herders who are highly dependent on natural resources and their relationship in CF and different types of PAs.

2.6. Climate change and the transhumance system

The main focus of this section is to present why climate change is a major concern in the study of transhumance systems and how the perceptions, observations and responses (adaptations) of local people from the agrarian societies help to advance understanding of climate change. Furthermore, the concept of climate change vulnerability, its dimensions and factors affecting climate change vulnerability are reviewed and presented.

2.6.1. Climate change scenario for Himalayas and Nepal

Climate change has emerged as a global concern (MEA 2005). Small island countries, least developed countries and countries with fragile ecosystems such as mountainous areas are particularly more vulnerable to climate change (Klein 2009). Climate change has increased the vulnerability of people whose subsistence livelihood depends upon the direct utilisation of natural resources (Tyler *et al.* 2007). It has posed existential threats to the way people live in some areas (Cockfield & Dovers 2013) and has emerged as an additional burden to the people in other areas (Gentle & Maraseni 2012; Perry *et al.* 2010).

Projected warming trend for 21st century is greater for South Asia (3.3°C) than the global mean (2.5°C) (IPCC 2007). Mountainous regions are comparatively more sensitive to climate change (Rangwala & Miller 2012). Due to its geo-political conditions and its potential impact on the economy, ecology, and environment, climate change is a major concern in the Himalayas (Liu & Rasul 2007). The rates of warming in the HKH region are significantly higher than the global average, and within the region, the rate is higher for the Central Himalayas (Nepal) (Shrestha 2009) and warming rates are progressively greater at higher elevations (Shrestha & Aryal 2011; Shrestha *et al.* 2012). In the high elevation areas where snowfall is the current norm, there will be increasing precipitation in the form of rain (IPCC 2007).

There is a consistent warming and rise in maximum temperature at an annual rate of 0.04 to 0.06°C in Nepal (NAPA 2010). Warming is more pronounced in the high altitude regions as compared to the low lands (NAPA 2010; Shrestha & Aryal 2011; Shrestha *et al.* 1999). This is likely to result in a decrease in snow cover duration in the Himalayan rangelands (Paudel & Andersen 2011). During the summer months, precipitation is projected to increase in the whole country in the range of 15 to 20 % (NAPA 2010). The large scale shift in the bioclimatic zones has been predicted in the Kailash Sacred Landscape that constitutes parts of Nepal, India and China (Zomer *et al.* 2014). Projected warming trends for many areas may change the timing of snow melts, grass production and phenology in the rangelands (IPCC 2007). The changing nature of precipitation might also impact vegetation dynamics and water availability in rangelands.

2.6.2. Perceptions of local people towards climate change

The indigenous and marginalised communities whose subsistence livelihoods depend upon direct utilisation of natural resources are the first and most affected by the climate change (Bardsley & Wiseman 2012; McDowell *et al.* 2013; Salick *et al.* 2009; Smith *et al.* 2001; Thomas & Twyman 2005) because they have little access to modern facilities, markets, health services and alternative means of production. They might have different experiences and knowledge than people adopting a modern lifestyle and living in urban areas (Howe *et al.* 2014; Tucker 1986; Wolf & Moser 2011). Many scholars (Alexander *et al.* 2011; Petheram *et al.* 2010; Sánchez-Cortés & Chavero 2011) have noted that indigenous knowledge could be better applied to the assessments of climate change. It has also been acknowledged for its role in advancing the understanding of knowledge of climate change (Chaudhary & Bawa 2011; Klein *et al.* 2014; Nelson *et al.* 2005).

The observations of local people often relied on holistic ways of knowing their environment that integrate a number of variables and relationships between them (Berkes & Berkes 2009). Local people use physical environmental indicators such as rain, first snowfall, melting of snow and biological indicators such as spring budding, leafing, blooming flowers and fruiting (Turner & Clifton 2009). Transhumant herders in the mountains of Nepal have to respond to nature's rhythm for characteristic seasonal movement of livestock. Their livelihood activities are based on direct utilisation of natural resources.

Perception of change in climate and biophysical indicators, and impacts of climate change are important in at least three ways. First, it is a driver of autonomous adaptations and behavioural response (Zheng & Dallimer 2015) that could, for example include changes to the grazing calendar or stocking rates. Second, the increased knowledge sharing between scientists, policy-makers and resource users may be one means of reducing vulnerability because new adaptation strategies could be generated from the combinations of knowledge. Third, it can be a form of citizen science, confirming or challenging modelled changes. This is more significant for the region as the region lacks empirical data of climate change. In addition, such studies advance the knowledge about the local effect of large scale global processes such as climate change.

2.6.3. Vulnerability to climate change: Concept, dimensions and analysis

Vulnerability is the state of susceptibility to harm from exposure to environmental change, and does not occur in isolation from the wider political economy and resource use. The distance to the city or district headquarters (Pandey & Jha 2012), wealth and well-being, class (Gentle *et al.* 2014; Macchi *et al.* 2014), gender (Arora-Jonsson 2011; Denton 2002; Gentle *et al.* 2014), and dependency on natural resources and livelihood options (Thomas & Twyman 2005) are related to vulnerability. Vulnerability also differs spatially and temporally (Fraser *et al.* 2011) even within the same communities. Hence, all communities are not equally vulnerable (Füssel 2010).

The indigenous communities following traditional lifestyle are recognised as highly vulnerable (Bardsley & Wiseman 2012; Furgal & Seguin 2006; Nilsson 2008; Salick & Byg 2007). The people involved in grazing based livestock production such as in transhumance systems could be more vulnerable than in other livestock production systems (Nardone *et al.* 2010; Thornton *et al.* 2009). The transhumance grazing is directly related to the timing of rainfall and grass production, agricultural seasons, persistence and melting of snow in rangelandsand availability of water near grazing. and climate change has the potential to affect these parameters (Ayanda *et al.* 2013; Dong *et al.* 2011; Tyler *et al.* 2007).

The three dimensions of vulnerability are adaptive capacity, sensitivity and exposure and these contribute to the overall vulnerability of the communities. The determinants of these dimensions, components and indicators vary significantly from system to system, sector to sector and region to region. For instance, adaptive capacity is uneven within and across communities and is also scale-dependent (Goldman & Riosmena 2013). Adaptive capacity reflects communities' resilience, resistance, flexibility and robustness (Smithers & Smit 1997) and is determined by a variety of system, sector and location specific characteristics (Goldman & Riosmena 2013; Yohe & Tol 2002). Natural and technological processes, and financial and social barriers also affect adaptive capacity (Jones 2010; Jones & Boyd 2011). Lack of communication between formal institutions and communities of practice can be a barrier to the adaptive capacity (Raymond & Robinson 2012). Similarly, the sensitivity and exposure of the communities also depends on various factors.

The challenges of vulnerability research are to develop robust and credible measures (Adger 2006). Some of the methodological challenges are related to spatial and temporal scales, aggregation and nonlinearity (Tonmoy & El-Zein 2013). In addition, the vulnerability of the communities is not always linked to the internal factors but the external pressure also affects it which make vulnerability research more complex. Sometimes, vulnerability might have been directly or indirectly influenced by government policies as seen in the communal pastoralists of the Kalahari (Dougill *et al.* 2010) and Tibet (Yeh *et al.* 2013) as government policies reducing mobility which is considered a strategy to deal with environmental change (Oteros-Rozas *et al.* 2013a). One of the approaches to compute and compare vulnerability is the indicator based vulnerability analysis (Hahn *et al.* 2009; Pandey & Jha 2012) in which climatic and non-climatic (socio-economic) indicators are used. This study uses this approach to compute and compare vulnerabilities of transhumant herders across study sites.

2.6.4. Climate change adaptation: An overview

Climate change might be a compounding factor to other change and processes in the rural areas. Transhumance systems that have been affected by labor migration and state public policies might suffer additionally because of climate change. Changes in temperature and rainfall affect soil moisture, quality and quantity of grass and water availability in the rangelands ultimately affecting livestock production. In addition, increased temperature can promote vectors and spread livestock diseases. Changes in timing of rainfall affect the seasonal calendar of herders and that can affect ecosystem management (Franco 2015). Furthermore, extreme climatic events such as snowstorms, heavy downpours and drought might increase due to climate change making natural disasters such as avalanches, landslides, flood or drought more frequent.

Globally, mitigation and adaptation are the two major policy responses to climate change. Adaptation is the adjustment in human or natural systems in response to climatic or environmental stimuli which buffer harm or exploit beneficial opportunities (IPCC 2001). Adaptation can be autonomous or planned, structural or behavioural, anticipatory or responsive, local or widespread. According to Smith *et al.* (2000), three elements: adaptation to what, who adapt and how adaptation occurs are important to fully understanding what adaptation is (Figure 2.4). Climate change adaptation has the potential to reduce adverse impacts of climate change and enhance beneficial impacts (Smit & Pilifosova 2001).

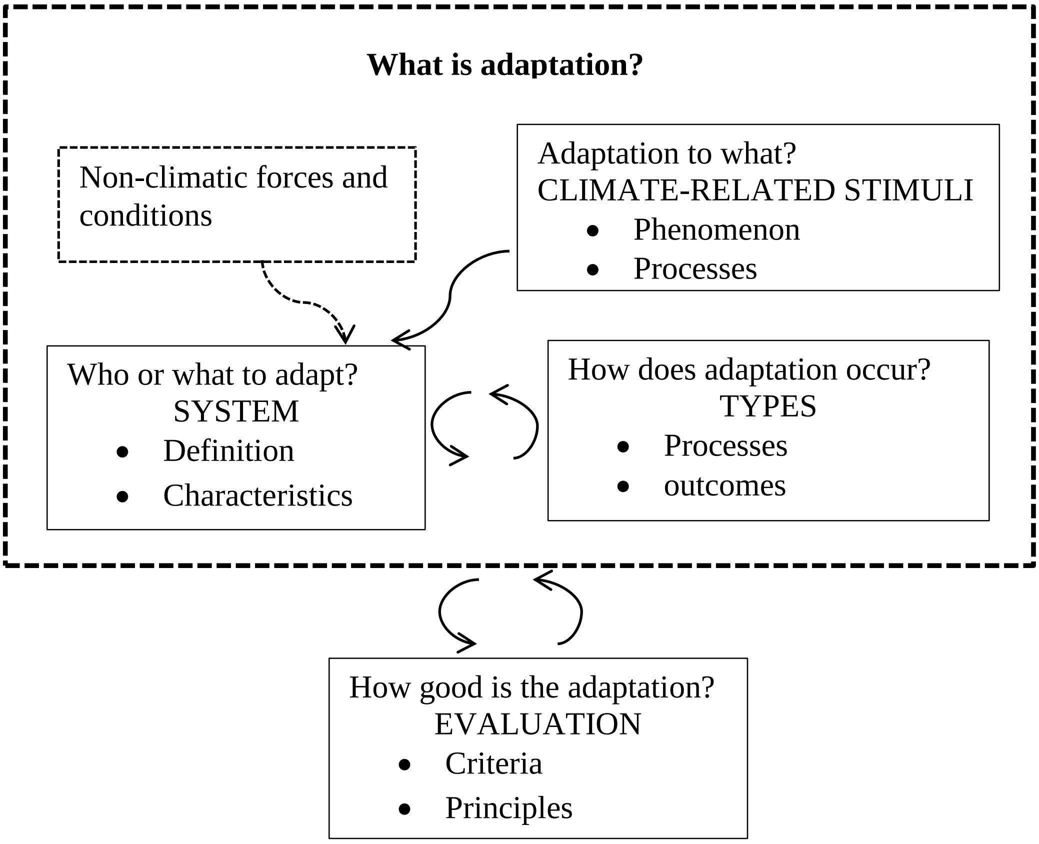

Figure 2-4: Gross anatomy of adaptation to climate change and variability; **Source:** Smit et al. (2000)

Climate change adaptation is a complex social process and understanding the magnitude of the adaptation challenge is incomplete (Berrang-Ford *et al.* 2011; Snorek *et al.* 2014). Adaptation strategies vary from sector to sector, community to community and place to place. Every response to the climate change is not good (Eriksen *et al.* 2011; Nyong *et al.* 2007) and social and environmental externalities of each response need to be considered. The adaptation practices that work for low levels of climate change might not work with high degrees of change. The adaptation measures that deliver short-term gains and economic benefit can lead to increased vulnerability in the medium or long run (Jones & Boyd 2011). The physical infrastructure, human resources and competent organisations play an important role in dealing with changing weather conditions. However, least developed countries such as Nepal are unable to manage them and weak governance aspects regarding climate change mitigation and adaptation is the worrying aspect (Banskota 2012).

2.6.5. Adaptation strategies in grazing based livestock production

People have developed different strategies to respond to climatic variability and uncertainty in the past. The strategies of people living in agrarian societies have also helped to reduce their vulnerability to climate change (Nyong *et al.* 2007; Yeh *et al.* 2013). Among others, people involved in pastoral livestock production including transhumance have developed different strategies to cope with environmental and resource variability (López-i-Gelats *et al.* 2015). The mobility, diversification, storage and communal pooling were the local adaptation strategies of Tibetan pastoralists (Fu *et al.* 2012). In Kenya, mobility, integration of livestock and crop, destocking, diversification of animal feed and changing livestock breed were identified as key adaptation strategies of agro-pastoralists (Silvestri *et al.* 2012). Mobility and communal pooling were the strategies for herders in Mongolia whereas diversification, storage and markets were major strategies in Inner Mongolia (Wang *et al.* 2013). These broad strategies comprise a range of local practices and spread risks across space, time and assets and hence reduce the vulnerability to climate change (Agrawal & Perrin 2009). The tactical strategies of herders largely depend on the herder's freedom of action but several non-climatic factors have eroded such freedom (Galvin 2009; Tyler *et al.* 2007). Furthermore, the local ecological knowledge and community based institutions also improve adaptation outcomes for pastoralists (Fu *et al.* 2012; Yeh *et al.* 2013). Therefore, it is important to identify the local adaptation strategies and to assess their effectiveness so that they can be integrated while designing and implementing adaptation strategies.

Although, it is suggested that climate change is more pronounced in the mountainous area of Nepal where transhumance is practiced and there are many indications that climate change can affect different aspect of the transhumance system, there is no information on how transhumant herders have perceived change in climate, how vulnerable are transhumant herders to the climate change and what are the local adaptation strategies of transhumant herders in the Himalayas.

2.7. Key conceptual questions from the review

In summary, the review on different aspects of the transhumance systems identified following four conceptual questions that need to be answered.

i) What are the drivers of changes to the transhumance systems how are they affecting socio-economic and culture of transhumant communities and transhumance systems?

ii) What are the trends and status of the transhumance systems under different change pressures?

iii) What are the likely socio-ecological impacts from the loss or decline of transhumance systems?

iv) What are the possible responses and future scenarios of transhumance systems?

To make a clear picture and generalise answers globally, replicated studies in multiple geographical areas, socio-political, economic and cultural setting are required. This study from the mountainous areas of Nepal can contribute in answering those questions representing the Himalayan region.

2.8. Human nature interaction: The theoretical perspective

The transhumance system involves people, livestock and rangelands and research problems (discussed in section 2.2.4) indicate that this study is multidisciplinary and covers both the social and ecological subsystems. No single theory or method can address the research questions in such a multidisciplinary field (Moran 2010) but the conceptual frameworks having their foundation in human-nature interactions (Liu *et al.* 2007) are useful. There are different disciplines which focus on the study of human-nature interactions. Some of them are political ecology, landscape ecology and social-ecological systems (SES).

2.8.1. Political ecology

Political ecology is a field of critical research on human-environment linkages (Brown 1998; Yeh *et al.* 2013). This is a powerful framework for interdisciplinary and multi-methodological studies that integrate studies of natural and social dynamics to examine multidimensionality (Little 2003; Peterson 2000). It helps to understand the complex interrelations between local people, national and global political economies, and ecosystems (Adams & Hutton 2007; Robbins 2012). Political ecology is a well-developed approach in natural resource management discipline (Little 2003; Yeh *et al.* 2013). This is helpful to analyse the complexities of society-development-environment interactions (Figure 2.5).

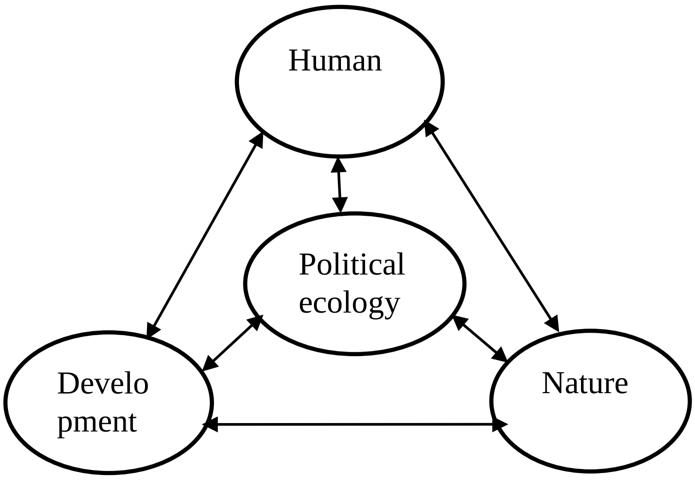

Figure 2-5: Human-nature-development interactions

There are different dimensions of political ecology which are relevant in this study. Historical and cultural political ecology (Bennett & Harris 1967) can highlight the historical and cultural context of the local agrarian communities (Little 2003; Widgren 2012). Political ecology of scale (Zimmerer & Bassett 2003) helps to understand how activities or changes at different spatial scale (local, state and global) influence the transhumance system. Since, transhumance systems in the mountains of Nepal have historically evolved and possess traditional knowledge and culture of local people, historical and cultural political ecology could be relevant to uncover these aspects. In response to endogenous and external factors different aspects of transhumance systems has changed, therefore, the ideas from political ecology of scale can help to understand changes and factors of changes at different scales.

Political ecology however, is neither a method nor a theory but it has developed as a dominant field of human-environment research (Robbins 2012; Walker 2005). There are important differences in the emphasis given by studies of political ecology and such studies have been criticised for the emphasis they placed on either social or ecological sphere. Some argue that political ecology involves politics without ecology (Vayda & Walters 1999; Walker 2005). However, others argue that natural scientists often put less emphasis on human behaviours and societies (Peterson 2000).

2.8.2. Landscape ecology

Landscape ecology is an open and inclusive field of research and offers a base for interdisciplinary studies (Fry 2001; Wu & Hobbs 2002). The cultural landscapes and multifunctional landscape concept are relevant in the study of human-nature interactions as both of these concepts stressed integration of bio-physical and social (human) aspects in the research.

The cultural landscape concept was developed in classical geography (Wu 2010) and has been very influential in human geography, nature conservation and landscape planning (Krichhoff *et al.* 2012; Wu 2010). One of the major factors that contributed to the recent popularity is due to its adoption by the International Convention for the Protection of the World's Cultural and Natural Heritage (often referred to as the World Heritage Convention) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1992. Cultural landscape concept reflects the declining power of pristine wilderness preservation and the realisation that human or human activities are components of the ecosystem (Phillips 1998). From the cultural landscape perspective, the domestication of nature by human beings is not only limited to plant and animal species but also ecosystems and landscapes (Kareiva *et al.* 2007). It assumes that the landscapes are not only the result of natural forces but also the consequences of human activities in a specific socio-economic and cultural context (Nüsser 2001). In other words, human activities and cultures are shaped by landscape features and human activities structure landscapes (Nassauer 1995). The concept stressed that the combined effect of nature and society becomes visible in cultural landscapes (Bürgi *et al.* 2004).

Landscapes provide a range of goods and services. The multifunctional landscape concept assumes that the landscapes are multidimensional and multifunctional (Naveh 2001; Tress *et al.* 2001). This concept stresses for a holistic approach for landscape research (Bolliger *et al.* 2011; Tipraqsa *et al.* 2007; Tress *et al.* 2001) and is useful to combine or detangle effects of multiple stressors in the landscape (Bolliger *et al.* 2011).

Transhumance landscapes in the Himalayas are cultural landscapes as they have been shaped by centuries of old pastoral activities. They comprise a mosaic of habitats with different productivity during the year and provide a number of ecosystem services. A cultural landscape approach could help to understand whether the transhumance practice in Himalayan rangelands is inseparable from components of natural ecosystems in the high Himalayas. The growth of tourism and implementation of different schemes of conservation which were used for subsistence grazing in the past indicate that the Himalayan rangelands are multifunctional landscape and the concept of landscape multifunctionality can be useful for this study.

Landscape ecology research however, suffers from the lack of comprehensive or integrated theories. Although cultural landscapes and multifunctional landscapes concepts emphasised the integration of bio-physical and social (human) systems, they are also still criticised as they are either society centred or ecology centred (Wu 2006). It has been argued that the landscape ecologists paid more attention to the biophysical than the socio-cultural aspects (Wu 2010). The imbalance and or separation between natural and social aspect in landscape research is counterproductive (Tress *et al.* 2001).

2.8.3. Social-ecological system

Recently, the concept of social-ecological systems (SES) has become increasingly popular in the discourse of human-nature interactions (Becker 2012). A SES is an ecological system intricately linked with and affected by one or more social systems (Anderies *et al.* 2004). Social-ecological systems consist of a bio-geo-physical unit and its associated actors and institutions (Glaser *et al.* 2012; Halliday & Glaser 2011). According to Ostrom (2009), resource systems, resource units, users and governance systems are subsystems of a SES. These systems are interrelated to each other, relevant ecosystems and linked to broader social, economic and political settings (Ostrom 2009). According to Glaser et al. (2010), SES comprises three elements for analysis: (i) a bio-geophysical system (e.g. ecosystem, coastal territory, rangelands); (ii) the associated social agents (individual and collective) with their institutions; and (iii) an identified problem context (e.g. resource overuse, pollution or ecosystem degradation).

Berkes and Folke (1998) started to use the term social-ecological systems to emphasize the integrated concept of humans in nature and stressed that the delineation between social and ecological systems is artificial and arbitrary (Berkes, Folke, *et al.* 2000). The 'social-ecological system' approach, therefore, indicates a commitment to adopt a holistic, systemic perspective towards human and non-human elements of a problem (Halliday & Glaser 2011). It is a vibrant, exciting endeavour that promises to link different disciplines into a new body of knowledge to solve the pressing problems (Cumming 2011). This approach is highly influential in the emerging sustainability science (Krichhoff *et al.* 2012). Some examples where SES approach has been used are: to study dynamic pastoral systems (Wang *et al.* 2014), to study ecosystem services (Carpenter *et al.* 2001; Martín-López *et al.* 2011), to uncover and understand social and ecological dynamics of protected areas (Cumming *et al.* 2015; Pollnac *et al.* 2010) and Coral reef (Cinner *et al.* 2012), to describe social and ecological values of seagrass meadows (Cullen-Unsworth *et al.* 2013), to develop classification system of small-scale benthic fisheries in Chile (Basurto *et al.* 2013) and to identify historical and current drivers of change in the Galapagos islands (González *et al.* 2008).

2.9. Contextualisation of the study: Social-ecological system and system thinking

The transhumance system can be considered as a dynamic social-ecological system (SES) consisting of rangelands, livestock and herders. The rangelands or pastures are the resource systems (ecological system); individual livestock, pasture or rangeland are the resource units; transhumant herders are the users and customary rules and institutions, indigenous knowledge, states rules and organisations constitute the governance systems in terms of Ostrom's SES framework (Ostrom 2009). Historically, this system was evolved as a main livelihood strategy for people in mountainous regions of Nepal when there were limited expectations/demands such as livestock grazing, collection of wild vegetables, fruits and medicinal plants from the mountainous rangelands. However, there are changes in the social-economic context of local people mainly driven by the influence of globalisation and different interests for the use mountainous rangelands have emerged that have changed demands from subsistence oriented to multi-functions. Government policies have tried to accommodate multi-functionality such as through the promotion of tourism and biodiversity conservation.

The studies of such SESs require a broader disciplinary approach that encompasses social and ecological systems. Until the past few decades, the point of contact between social sciences and natural sciences was very limited in dealing with SES. Ecological studies often excluded humans from the study of ecology and many social science disciplines had ignored environment altogether (Berkes *et al.* 2003). The disconnect between biological knowledge and conservation success has developed growing attention that reductionist approaches, on either end of the social/ecological spectrum, cannot deal with the complex phenomenon comprising interacting variables (Mascia *et al.* 2003).

The current understanding in natural resource management is that no natural environment is exempt from human inputs and natural resources should be examined as a whole including the human components if we wish to protect and manage them in a sustainable way (Krause & Welp 2012). The social sciences complement the biological sciences in critical ways (Blythe 2012) informing local, national, and international conservation efforts (Mascia *et al.* 2003) and it has been realised that disciplinary boundaries cannot cope with complex problems (Ludwig *et al.* 2001; Rosa & Dietz 1998). The systems thinking bridges the social and biophysical sciences (Allison & Hobbs 2004) and replaced the view that resources can be treated as discrete entities in isolation from the rest of the ecosystem and social systems (Berkes, Folke, *et al.* 2000). The conventional approaches with the focus on either side of social-ecological systems fail to achieve comprenhensive understanding of the complexity. System thinking is powerful to uncover complexities within the system (Darnhofer *et al.* 2011; Van Mai & To 2015; Walker *et al.* 1998).

Cumming (2014) provides a typology of frameworks and suggested different criteria for satisfactory theory oriented frameworks. Binder *et al.* (2013) compared different frameworks used to analyse the SES and emphasised that the framework used to study SES should balance orientations towards ecological and social dimensions. Most of the frameworks have their origin and focus in one dimension but the social-ecological systems framework (Ostrom 2007a, 2009) is a multilevel nested framework that treats the social and ecological systems in almost equal depth (Binder *et al.* 2013). However, the selection of frameworks largely depends upon the research questions, the focus of the study and the interest of researchers (Cumming 2014). In many cases, more than one framework could be useful to deal with specific research problems within a subsystem of SES.

This study considers transhumance systems as SESs. The study of such SESs is necessarily an interdisciplinary field and requires a hybrid research (combining tools and methods of both the social and natural sciences) method and a system thinking approach. Systems thinking helps to reveal a web of relationships among multiple drivers and factors operating in a complex system (Van Mai & To 2015). The Driver-Pressure-State-Impact-Response (DPSIR) framework (Figure 2.6) developed by European Environmental Agency (EEA) provides a system thinking approach to the relations between environmental (ecological) and human systems (EEA 1999). Political ecology, landscape ecology and SES thinking are interrelated to each other which provided the conceptual foundations while considering different aspects (specific objective and research questions) of the study. Same was also true with the vulnerability framework that was used to study the vulnerability of transhumant herders to climate change. Although individual aspects of the research were dealt with these conceptual foundations, the broader framework that can bring all these concepts together and can incorporate all aspects under study was realised. It was found that the systems thinking was required to put diverse ideas and findings together. The DPSIR framework that provide systems thinking approach and can bring together all the aspects researched in this study. Therefore, this framework was used as an overall framework of the study.

DPSIR framework is simple and transparent and has the ability to integrate socio-economic factors with natural sciences (Yee *et al.* 2015). This framework is also used to analyse SESs (Cumming 2014; Potschin 2009) and provide effective solutions to the real world problems based on knowledge integration, stakeholder involvement and provision of alternatives (Tscherning *et al.* 2012; Xue *et al.* 2015). This framework is an interdisciplinary tool to present knowledge on the state and cause-effect relationships (Bell 2012; Bürgi *et al.* 2004; Lundberg 2005; Roura-Pascual *et al.* 2009) and helps to understand the human-nature interactions in SES (Nassl & Löffler 2015). The framework is useful to overcome the communication gap between science and policy (Smeets & Weterings 1999) and produces a number of response options rather than a single solution to the decision makers (Tscherning *et al.* 2012). This study uses the DPSIR framework to discuss findings on major drivers of change in transhumance systems, state of transhumance systems (or major changes), likely impacts from those changes and possible responses in a meaningful way.

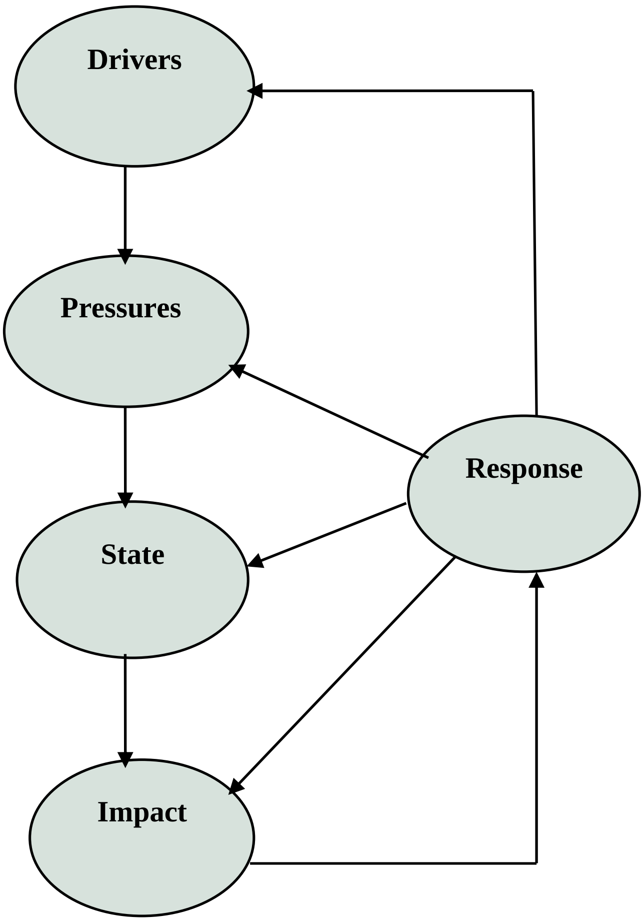

Figure 2-6: Driver-Pressure-State-Impact-Response (DPSIR) framework; **Source:** EEA (1999)

2.10. Conclusions

Seasonal and recurring movement of livestock is the key feature of the transhumance system. Vertical transhumance in the high Himalayas evolved as one of the most important livelihood strategies to use the grazing resources distributed at different altitudes. Similar to other traditional practices, the transhumance system has been constrained by different factors and has shown a declining trend. Some of the factors affecting the system are related to social-economic and cultural change brought about by globalisation, whereas others are related to change in government policies and global environmental changes.

Perceptions and attitudes of local people help to understand relationships between conservation measures and local people. Previous studies have treated all local people as a population of the study; however, local communities are not homogenous (Adhikari *et al.* 2004), the dependency of local people upon the natural resources within the community varies; they are not equally affected by the restriction on resource use and there may be multiple relationships between conservation and local people. Furthermore, perceptions of local people from agrarian societies towards climatic variables might be useful to advance understanding of climate change because their daily activities are directly affected by these variables and have to respond accordingly. Transhumant herders in the mountains of Nepal offer a good example to study the perception and attitude of local people towards different schemes of conservation and climate change.

The transhumance system comprises rangelands, livestock and herder (people). The human-nature interaction is a key element of the transhumance system. Therefore, this study will borrow ideas from political ecology, cultural landscapes and social-ecological systems which are used in the study of human-nature interactions. A dynamic SES perspective has been chosen as a broader framework of the study. However, a review suggests that different theories or frameworks are relevant in each dimension; social-economic and cultural, ecology, law and policies and climate change. For instance, an intermediate disturbance hypothesis is proposed to explain ecological role of transhumance in the rangelands and an indicator based vulnerability framework is proposed for climate change vulnerability analysis. The DPSIR framework has been proposed to synthesise the findings on drivers of change and major changes in transhumance systems, associated impacts from changes and possible responses.

Chapter 3 : Study areas, methods of data collection and analysis

3.1. Introduction

The previous two chapters covered the background and research problems, goals and objectives (chapter 1), and contextualisation of the study through relevant literature (chapter 2). From the literature, I showed that the pastoral livestock productions in general and transhumance systems in particular are constrained by a range of factors. The likely social and ecological impacts of loss of a transhumance system are poorly understood elsewhere and there is no information from the Himalayan region. Transhumance systems are social-ecological systems (SESs) and so a dynamic approach to the research has been proposed for the study that requires a range of research tools and techniques. The aim of this chapter is to outline where and how the study was conducted. First, I present an overview of the study areas and then I introduce methods used for data collection and analysis.

3.2. Study areas

3.2.1. Selection of study areas

The study areas were selected so that the important variables affecting transhumance systems could be examined, while minimising the cost of field-work. Most obviously, these had to be sites with significant and extant transhumance herding, which means mountain zones, as previously described. Since, base climate varies by altitude, topography and especially from east to west the observed and expected impacts of climate change may be quite variable. So a range of sites capturing some of this variation was needed. Labour out-migration is widespread across Nepal but there are local variations, as is the case with tourism with some iconic areas having much higher levels of activity than more remote locations, so again, a spread of sites was necessary. Finally, the sites should ideally have one and preferably both of community forests (CFs) and protected areas (PAs) cutting across herding pathways.

The selection of sites involved multilevel, multistage and multi-stakeholders processes, starting with consultation with the Department of National Parks and Wildlife Conservation (DNPWC), National Trust for Nature Conservation (NTNC) and Department of Livestock Service. This resulted in the selection of three PAs namely; Sagarmatha (Mt. Everest) National Park (SNP), Gaurishankar Conservation Area (GCA) and Khaptad National Park (KNP), each of them selected to represent the Eastern, Central and far-Western development region of Nepal respectively (Figure 3.1). Then, one Village Development Committee (VDC) for each of the PAs was selected either inside or from surrounding areas.

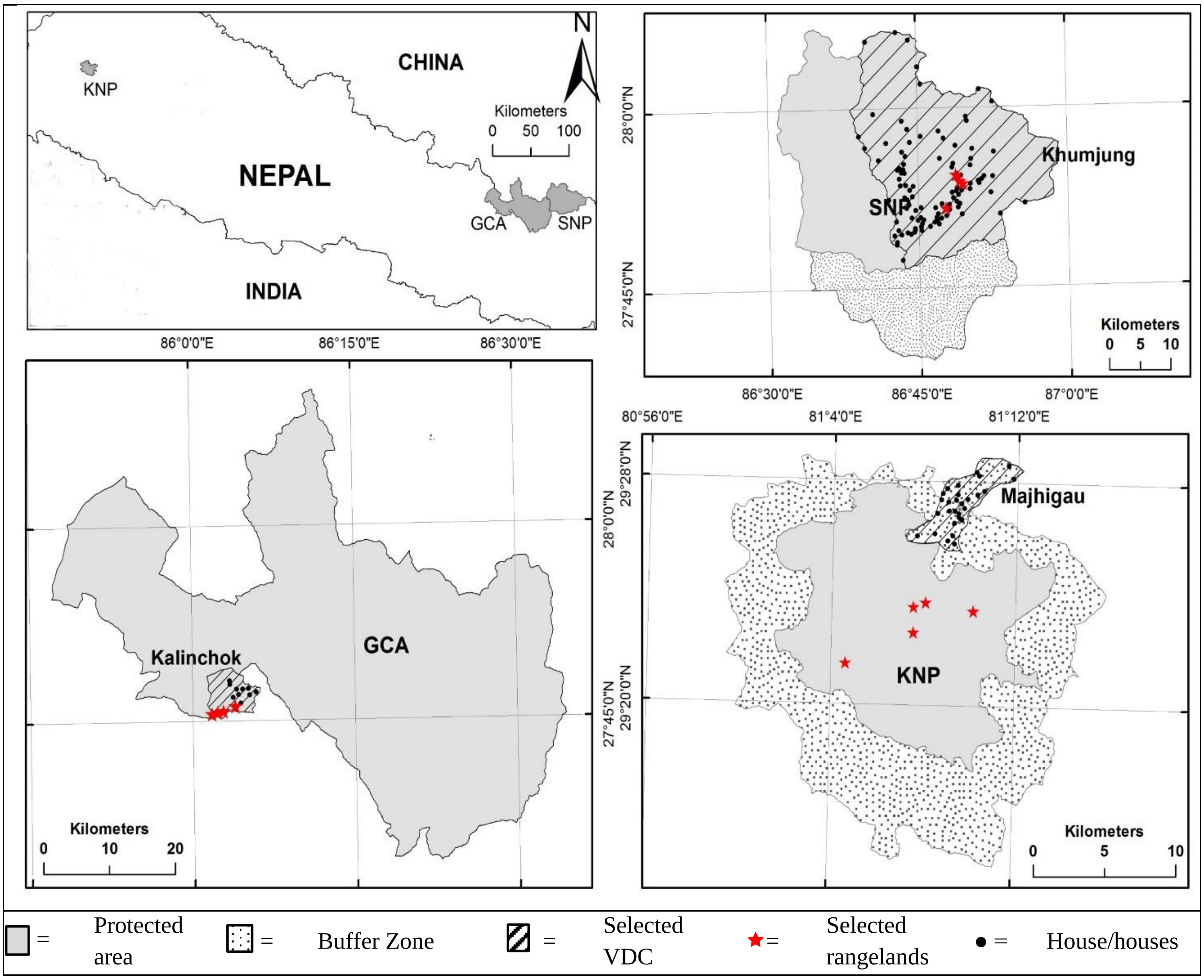

Figure 3-1: Map showing selected protected areas (PAs), Village Development Committees (VDCs), and location of selected rangelands; SNP = Sagarmatha National Park, GCA = Gaurishankar Conservation Area, KNP = Khaptad National Park

The VDCs were selected after consultation with government agency staff from the selected PAs. The VDCs where transhumance was more common compared to other surrounding VDCs, and from where a large number of herders graze livestock inside the selected PAs, were considered for the study. Transhumant herders from each of the VDCs were interviewed and invited to the focus groups. Transhumant herders who grazed in the rangelands of respective PAs were consulted to identify the rangelands for the vegetation sampling and ecological study. All of the selected rangelands were located inside selected PAs and were main rangelands for the herders of selected VDCs. In some cases, there was no overlap or encompassing of settlements and PAs, therefore, herders to study social subsystems were from selected VDCs. These VDCs were Khumjung of Solukhumbu District for SNP, Kalinchok of Dolakha District for GCA and Majhigaun of Bajhang District for KNP (Figure 3.1). The selection of multiple sites and comparison across sites offer a broader and holistic perspective to generalise the findings throughout the mountainous region of Nepal and beyond.

3.2.2. Description of the selected areas

The selected PAs are in the mountainous region of Nepal. There are marked variations in temperature and rainfall with altitude and season. The climate of the whole country (Nepal) is largely influenced by monsoons originating in the Bay of Bengal, entering Nepal from the eastern part and then moving across to the western part of the country. Seventy to eighty percent of total annual precipitation occurs in the monsoon season (June-September). High altitude mountainous regions receive snowfall in winter season. The transhumance system of livestock production historically evolved in all three PAs. Similar to other areas in the mountainous region of Nepal (also in other countries of Himalayan region), herders graze the rangelands located at high altitude of these PAs in the monsoon season, moving to the forests and private agricultural lands near settlements in winter.

There are, however, some differences between sites, including in climate (mainly difference in rainfall from east to west) and elevation and the associated differences in biological factors such as forest and vegetation types. For instance, SNP gets higher rainfall since total rainfall gradually decreases from the eastern to the western part of Nepal. GCA is the largest in size among selected PAs whereas KNP is the smallest. The elevation range was the highest in GCA and least in KNP. Since the elevation of SNP starts at about 2800 m above sea level (m asl) and the climate is cold, few crops are possible and the productivity is also low. Therefore, crop diversity and productivity are higher in GCA and KNP than in SNP.

Second, the selected PAs differ in terms of history of establishment, their International Union for Conservation of Nature (IUCN) category and management objectives (Table 3.1). SNP was the oldest PA, established in 1976 (about 40 years ago). KNP was established in 1982 (32 years ago) and GCA in 2010 (just five years ago). GCA is still in the process of establishing infrastructure and finalising a management plan. SNP and KNP belong to IUCN category II whereas GCA belongs to category VI. The management objectives for various category of PAs is different and the level of restriction for resource use and participation of local people is less restricted going from category I (1a-strict nature reserves and 1b- wilderness areas) to VI (PAs with sustainable use of natural resources).

Third, there are settlements inside SNP and GCA but not in KNP. The people inhabiting PAs graze livestock inside SNP and GCA whereas people of surrounding areas graze livestock inside KNP. Herders from SNP and GCA do not pay fees to graze livestock in the high elevation rangelands as they are residence within PAs. However, herders who graze livestock inside KNP have to pay fees to graze livestock and are only allowed to graze in designated areas and time.

Fourth, SNP is inscribed in the UNESCO’s World Heritage List but not GCA and KNP. The inclusion of SNP in this list helped to publicise this area as one of the major attractions for tourists. Tourism started when Mt. Everest was first summited in 1953 and by 2013 there 36,750 tourists visiting the area (*Nepal Tourism Statistics 2013*). The drop in number of tourists visiting the area during 2001-2007 is due to the political conflict in the country. However, tourism in the other two sites (KNP and GCA) is almost absent, with only 19 tourists visiting KNP in 2013 (*Nepal Tourism Statistics 2013*).

Table 3-1: General overview of the selected protected areas (PAs)

Features	Sagarmatha National Park (SNP)	Gaurishankar Conservation Area (GCA)	Khaptad National Park (KNP)
Designation (year)	1976	2010	1984
Area (sq km)	1148	2,179	225
Altitude (m asl)	2,800-8,850	<1,000->8,000	1,400-3,300
Relevant Act	*National Parks and Wildlife Conservation Act* (1973)	*National Parks and Wildlife Conservation Act* (1973)	*National Parks and Wildlife Conservation Act* (1973)
Relevant rules/regulation	*Mountain (Himalayan) Park Regulations* (1980)	*Conservation Area Management Rules* (1996)	*Khaptad National Park Regulations* (1988)
IUCN's Category	II	VI	II
Listed in UNESCO's World Heritage sites	Yes	No	No
Settlement inside PAs	Yes	Yes	No
Transhumance system	Yes	Yes	Yes
Buffer zone and its area (sq km)	Yes	Not applicable in CA	Yes

3.2.2.1. Sagarmatha National Park

Sagarmatha National Park (SNP) was declared in 1976 by the Government of Nepal (GoN). SNP covers an area of 1,148 sq.km and the elevation ranges from 2,800 to 8,850 m asl (Table 3.1). The park includes the whole of Namche and Khumjung VDCs of the Solukhumbu District. The Chaurikharka VDC of this District was declared as a Buffer Zone (BZ) of SNP in 2002 and BZ in Nepal means the peripheral area of national park or wildlife reserve developed as a part of a larger integrated conservation and development programme to reduce conflict between communities and parks (Heinen & Mehta 2000). IUCN's management category of SNP is II. This category of PAs does not permit resource use other than subsistence use by inhabitants or minor recreational opportunities (tourism).

The highest mountain in the world, Mt. Everest (8850 m asl) lies in SNP. Other major peaks inside SNP are Lhotse (8501 m asl), and Cho Oyu (8153 m asl). The SNP is inscribed in the World Heritage List since 1981 due to its physical, biological and cultural significance. This made SNP a popular tourist destination with mountaineering and tourism which was started in the areas since 1950 (Daconto & Sherpa 2010). The increased number of tourists in SNP has offered additional income opportunities and attracted many local people towards tourism related business. Many families in SNP, particularly near trekking routes have given up animal husbandry. Herding camps which were used historically, developed into tourist villages. Tourism has added pressure to the alpine vegetation and forests (*SNP Management and Tourism Plan* 2007; Garbarino *et al.* 2014; Keiter 1995) due to increasing demand for timber for lodge construction, fuel wood for cooking and space heating and the accumulation of solid waste.

The climate of SNP is moist and cool in summer and cold and dry in winter (*SNP Management and Tourism Plan* 2007). SNP receives an average of about 1000 mm of precipitation (Sherpa 2008). The climatic variation along the elevation gradient are reflected in different bioclimatic zones (Sherpa & Bajracharya 2009). SNP is rich in floral and faunal diversity due to diverse habitat types ranging from temperate to nival zones. Forests and rangelands occupy 6.28% and 21.41% of the total areas respectively in SNP and its BZ (Bhattarai & Upadhyay 2013). Much of the upper elevation landscapes between 3500 and 5000 m asl are dominated by shrubs and grasslands. The diverse landscape of SNP has been shaped by human use for centuries (Sherpa & Bajracharya 2009). Main human activities are livestock grazing and the collection of grass and medicinal plants. The main mammals are snow leopard (*Uncia uncia*), red panda (*Ailurus fulgens*), musk deer (*Moschus chrysogaster*), Himalayan black bear (*Selenarctos thibetanus*) and Himalayan tahr (*Hemitragus jemlahicus*). Many of these are endangered and threatened species and are protected wildlife of Nepal.

The traditional economic activities of the people in SNP were subsistence agriculture and animal husbandry supplemented by trade across the Himalayas i.e. with Tibet (*SNP Management and Tourism Plan* 2007). Less than 10% of the land is cultivable where limited crops such as barley, buckwheat and potato are grown. This increased the dependency of local people on livestock relative to agriculture. The main livestock in SNP are yaks/naks, cows/bulls, *chauri/jokpyo* (hybrid of yaks/naks and cows/bulls and vice-versa) and horses. Livestock production is still an important livelihood activity for economically marginal families (*SNP Management and Tourism Plan* 2007). Therefore, threats to the transhumance system can ultimately threaten the livelihood of vulnerable people.

3.2.2.2. Gaurishankar Conservation Area (GCA)

Gaurishankar Conservation Area (GCA) is situated in the Central northern part of Nepal. It was declared by a special meeting of the Council of Ministers, Government of Nepal held at Kala Patthar (5542 m asl) near base camp of the Mt. Everest in

Khumjung VDC of Solukhumbu District in 2009. The purpose of such a cabinet meeting held at the highest altitude was to draw the attention of international communities to the effects of climate change in the Himalayas, and also to demonstrate Nepal's commitment and solidarity to the fight against climate change. GCA borders SNP to the east and Langtang National Park to the west. GCA was the largest and the youngest among the three selected PAs and encompasses parts of three Districts viz. Sindhupalchok, Dolakha and Ramechhap. Within 120 km, the altitude ranges from less than 1,000 to over 8,000 m asl.

GCA is category VI where the primary objective is to protect natural ecosystems and to promote the sustainable use of natural resources, where conservation and sustainable use can be mutually beneficial. Therefore, there is likely to be less restriction on production uses in GCA than in SNP and KNP.

The elevation of GCA starts from below 1000 m asl, compared to 2800 m for SNP. Therefore, the climate of GCA ranges from a sub-tropical to an arctic type. The areas, above tree line are alpine rangelands. Forests together with shrubs account for 46% of GCA with 36% as barren and other land. About 10% of the total area is agricultural land and grasslands 8% (*GCA Management Plan (2012-2016)* 2013). Similar to the SNP, mammals that are found and listed in GCA as endangered or threatened are the snow leopard (*Uncia uncia*), red panda (*Ailurus fulgens*), musk deer (*Moschus chrysogaster*), Himalayan black bear (*Selenarctos thibetanus*) and Himalayan tahr (*Hemitragus jemlahicus*).

Similar to the highland dwellers in other mountainous areas of Nepal, animal husbandry is one of the main livelihood activities for the people. About 80% of households (HHs) keep some kind of livestock (*GCA Management Plan (2012-2016)* 2013). For some people, it is more important than agriculture because agricultural production is limited by cold climate and other geo-physical hindrances in high elevation. There are summer and winter rangelands in high and mid-mountain areas supplying forage for livestock. Rangelands that are grazed in summer are generally located above or near the tree line but winter pastures are either located in villages (agricultural land) or forests near to the villages.

3.2.2.3. Khaptad National Park (KNP)

The Khaptad National Park (KNP) was established in 1984 following the advice of Hindu holy man, Khaptad Baba, who contributed to the conservation of local culture and biodiversity in the area (Kollmair *et al.* 2003). KNP lies in far-Western Nepal and represents the middle mountain ecological region of Nepal. Similar to the general pattern in Nepal, most precipitation falls between June and September. With an area of 225 sq km, KNP is the smallest of three PAs selected for the study and is one of the least explored areas of Nepal (Kunwar 2003). The elevation of KNP ranges from 1,400 to 3,300 m asl. KNP lies at the intersection of four Districts namely Bajhang, Bajura, Doti, and Achham. Its Buffer Zone (BZ) was declared in 2006 with an area of 216 sq km that includes parts of 21 VDCs from the adjoining four Districts. Similar to SNP, IUCN's management category of KNP is II.

The central area of the KNP is flat and peripheral areas consist of steep slopes. Several rivers and streams originate from KNP and flow in a radial drainage pattern providing water for downstream populations. KNP has a unique landscapes consisting of 22 moorlands locally called *patans* which are major attractions of the area. These *patans* are grazing land for the people living in the surrounding areas (Mishra 2000). In the core area of the park, there is a 'sacred zone' of about 5 sq km that encompasses an important holy place and *ashram* (hermitage) of Khaptad Baba. At this place of 'meditation and silence', grazing, felling trees, killing animals, as well as consumption of alcohol and tobacco are prohibited at any time (Kollmair *et al.* 2003).

Forest covers 90% of the park area, with grass and shrub covering 7%. The rangelands inside KNP are important for people residing in the BZ and having a livestock based livelihood. Unlike in SNP and GCA where there are settlements inside PAs, and rangelands were used by inhabitants of the PAs, there are no settlements inside KNP and herders from surrounding areas of the park graze livestock inside the park for some time of the year. Grazing areas inside KNP were historically divided among herders of four Districts (Acham, Bajura, Bajhang and Doti) before the establishment of KNP (Mishra 2000). The division was based on proximity to the park, availability of other pasture lands and physical accessibility (Kollmair *et al.* 2003). KNP collects fees from herders (*Khaptad National Park Regulation* 1988).

Herders keep their livestock in *bari* (rain fed agricultural and other private land) settlements for about two months to manure the fields. During winter, livestock are moved to stables at the lower elevation (*aul chana*) and brought to the higher elevation (*lekh chana*) in summer. In winter, the livestock are fed with agricultural residue such as paddy and wheat straw, by-products of grains, and tree fodder to supplement grazing. Farmers are allowed to graze their livestock and build *goths* inside KNP from Mid-May to Mid-September.

3.2.3. Description of the selected VDCs

Village Development Committees (VDCs) are small, local administrative units of the Government of Nepal (GoN). One VDC from each selected PA was selected which represented the most active transhumance systems in each area. A general overview of selected VDCs is given below (Table 3.2).

All of these VDCs are located in remote areas of the higher Himalayas characterised by rugged terrain and are less accessible. They can be reached only by trekking (3 days trekking for Khumjung from Lukla, 1 day trekking for Kalinchok from Charikot and 2 days trekking for Majhigaun from Dipayal) following travel by aeroplane and/or vehicle from Kathmandu to the nearest points. In all VDCs, the transhumance is based on vertical movement of livestock. Furthermore, animal husbandry and crop production are integrated in all VDCs.

3.2.3.1. Khumjung

Khumjung is one of the two VDCs of the SNP and one of the 34 VDCs of Solukhumbu District. This lies in Khumbu, a sacred hidden valley of Sherpa people in the lap of the world's highest ecosystems (Sherpa & Bajracharya 2009). Sherpa ancestors settled in Khumbu area some 500 years ago (Sherpa & Bajracharya 2009; Stevens 2003). Sherpa people of Khumjung follow Buddhism and don't slaughter livestock or poach wildlife (Karan & Mather 1985). The total numbers of HHs in the Khumjung are 551 with a population of 1912 (CBS 2012) of which 90% are Sherpa. The major settlements of the VDC are Kunde, Khumjung, Phortse, Pangboche and Dingboche.

Table 3-2: General overview of the selected VDCs

Features	**Khumjung**	**Kalinchok**	**Majhigaun**
District	Solukhumbu	Dolakha	Bajhang
Ecological zone	Mountain	Mountain	Mountain
Development region	Eastern	Central	Far-western
Location of settlement	Inside SNP	Inside GCA	In the BZ of KNP
Total number of HH*	551	541	787
Population*	1912	2806	4032
No. of HHs having livestock**	176	352	636
Dominant caste	*Sherpa*	No single dominating caste but majority are of indigenous nationalities	*Chhetri*
Dominant religion	Buddhism	Mixed	Hinduism
Presence of transhumance system	Yes	Yes	Yes
Livestock types	Yak/nak, *Chauri/jokpyo*, cow/ox, horse	Goat, cow/ox, buffalo, *Chauri/jokpyo*	Cow/ox, goat, buffalo, horse
Tourism	High	Almost nil	Almost nil
Overseas labor migration	Low	High (to Middle east countries and Malaysia)	High (to different cities of India)
Major crops grown	Potato, barley buckwheat	Millet, barley, wheat, maize	Maize, rice, wheat, millet
Food sufficiency (months) **	< 3	4	9

Source: *CBS (2012), **Livestock census (2013)

The livelihood of people in Khumjung is based on pastoralism, agriculture and/or tourism (Sherpa & Kayastha 2009). The traditional occupations of local people were livestock rearing, agriculture and trade. Local people specialise in the herding and breeding of livestock. They practice transhumance with yak/nak, *chauri/jokpyo* and cattle (Sherpa & Kayastha 2009). In summer, livestock are grazed in highland rangelands and they are brought to the lower elevation when snow covers these rangelands in winter. Among three selected VDCs, the transhumance system of the Khumjung (lies in Khumbu) has been studied and described by the many authors (Brower 1992; Fürer-Haimendorf 1975; Stevens 1993) whereas the remaining two sites have scarce information. The landscape around Khumjung showed significant livestock impact (Spoon 2011), with many conspicuous terracotta on the sub-alpine and alpine slopes of Khumbu caused by both livestock and herders (Lhakpa Norbu 2008).

At the time of the study, most of the villagers were engaged in some aspects of tourism business (*SNP Management and Tourism Plan* 2007; Karan & Mather 1985) and the number of livestock and herding families have been declining (Spoon 2013). Khumjung is more dependent on tourism compared to neighbouring VDCs and VDCs considered for other study sites (GCA and KNP) as it encompasses Mt. Everest. However, tourism has been continuously growing in other mountainous region of Nepal including Langtang, Annapurna, Manaslu where trekking routes are developed. In Khumjung, tourism has not only affected the number of herding families and herd composition but also the preference of livestock gender (male or female) within the same livestock type (Padoa-Schioppa & Baietto 2008; Sherpa & Bajracharya 2009). The other way tourism affected herding activities in Khumjung is by creating labour shortage because a significant portion of active labour started tourism related businesses (*SNP Management and Tourism Plan* 2007; Sherpa & Bajracharya 2009). The Sherpa’s lifestyle and traditional culture are also eroding because of their interaction with outsiders (*SNP Management and Tourism Plan* 2007; Karan & Mather 1985).

3.2.3.2. Kalinchok

Kalinchok is one of 22 VDCs of GCA and one of 52 VDCs of Dolakha District. The total numbers of HHs in Kalinchok are 541 and the population is 2806 (CBS 2012). About 21.4% of the total land in Kalinchok is covered by cultivated land where maize and wheat cultivation is possible because the elevation is lower than that of Khumjung. Forests cover 47.8% of the total land, and grasses and bush cover more than 30% of the VDC area. People of different ethnic groups (communities) such as *Thami*, *Tamang*, *Sherpa*, *Gurung* and *Newar* live in this VDC. The higher elevation area is mainly inhabited by *Tamang* and *Sherpa* whereas the lower part is largely inhabited by *Thami*, *Newar*, *Gurung* and *Chhetri*. There is a difference in the livestock types owned by people from different ethnic groups. For instance, *Sherpa* and *Tamang* are engaged in *Chauri* rearing, *Newar* in goat rearing, and *Thami* and *Chhetri* in cattle and buffalo rearing. The overall literacy rate of the VDC is only 19.5 % (*GCA Management Plan (2012-2016)* 2013) which is far below the literacy rate of the country.

The livelihood of the people living in Kalinchok is based on subsistence agriculture and livestock production. These two economic activities complement each other. The local agricultural production is sustained for only four months of the year (*GCA Management Plan (2012-2016)* 2013) which is more than that of Khumjung where local production lasts for less than three months. Major crops grown are wheat, barley, millet and maize.

More than 30% of the total HHs income comes from livestock rearing which is more than what is obtained from agriculture (*GCA Management Plan (2012-2016)* 2013). The livestock types include cattle (cows/oxen), buffaloes, goats and *chauri*. Livestock production follows the transhumance system in Kalinchok (Charmakar 2012). Most of the villagers move their livestock to the high altitude rangeland in summer months and bring back to villages and CFs nearby villages in winter months (Parajuli *et al.* 2013). *Chauri* rearing is more heavily dependent on grazing, therefore they frequently move to different grazing areas throughout the year and they use rangelands located at great distances from settlements.

All grazing areas used in different seasons of a year by the herders of Khumjung are inside the park and herders from Khumjung do not use or travel through community forestry. However, some of the forest and grazing areas in Kalinchok were managed as community forestry until the GCA was declared five years ago. Even after the declaration of GCA, the existing Community Forests Users Groups were not completely dissolved, being converted to a Conservation Area Management Committee (CAMC) by GCA. Similarly, the herders of Majhigaun (see later description) have also to use CF to graze livestock during the winter season. Therefore, herders of Kalinchok and Mjahigaun had experience with CF and were able to comment on how CF has affected the transhumance system.

Similar to the increasing trend of youth migration from Nepal, youth migration in Kalinchok in search of jobs has increased considerably in recent years. Almost one third of HHs have at least one family member working overseas (mainly in Middle East countries: United Arab Emirates, Saudi Arabia, Qatar, Kuwait, and Israel; and Malaysia) (HHs survey, 2013). This has increased HHs income and there is an increasing trend for such families to migrate to the District's headquarters and Kathmandu. This has created a labour shortage for the traditional agriculture and livestock production in general, and transhumance system in particular.

3.2.3.3. Majhigaun

Majhigaun is one of the 21 VDCs in the BZ of KNP and one of the 47 VDCs of Bajhang District in far-Western Nepal, an area extremely impoverished even by Nepalese standards (Thieme & Müller-Böker 2004). The total number of HHs in the

Majhigaun is 788 with the total population of 4032 (CBS 2012). Six wards (1, 2, 3 4, 5 and 7) out of nine lie in the BZ of KNP (*KNP and BZ Management Plan* 2005). *Chhetri* is the dominant caste in Majhigaun and all people belong to the Hindu religion. Almost all HHs in Majhigaun practice farming and animal husbandry (*KNP and BZ Management Plan* 2005). The major income sources are agriculture, livestock, labour and foreign jobs. The major crops include rice, maize, wheat and millet. Rice cultivation is possible in the lower belt of Majhigaun because of higher temperatures than in Khumjung and Kalinchok. Local agricultural production can last for about nine months to feed the local population (*KNP and BZ Management Plan* 2005) which was considerably higher than in the other two sites (>3 months in Khumjung and about 4 months in Kalinchok). The livestock types for Mahigaun include cow/bulls, buffaloes and goats and horses. People move their cattle to the high elevation rangelands inside KNP in the summer season when rangelands are open for grazing. In the remaining months they graze their livestock in the vicinity of the KNP and forests nearby their village.

Unlike in Khumjung and Kalinchok, where most of the youth are involved in tourism related business (activities) and overseas migration to countries other than India, the people of Bajhang District including Majhigaun VDC move to Indian cities seasonally for supplementary income (Thieme *et al.* 2003; Thieme & Müller-Böker 2004). They leave the village once they plant crops in the field and come back to harvest crops and celebrate *Dashain*, which is the biggest festival. In between crop planting and harvest, they work in different cities of India including New Delhi to earn cash for essential goods to run the family.

3.3. Methods of data collection

The selection of data collection and analysis techniques largely depend on the philosophical perspective i.e. whether the philosophical perspective of the research is positivism or subjectivism. The basis for most of the researches in the natural sciences is positivism whereas it is subjectivism in social science (Evely *et al.* 2008; O'Gorman & Maclntosh 2015). According to Evely *at al.* (2008), there are seven different philosophies (extreme positivism, structural realism, critical realism, transcendental realism, hermeneutics, nominalism and extreme subjectivism) along the positivist-subjectivist continuum. This study is multidisciplinary in nature and cover both natural science and social science. Therefore, the extreme position in either side of positivism-subjectivism continuum is not useful and it can be positioned almost in the middle of these two extremes somewhere around critical realism and transcendental realism. The study of a Social-Ecological System (SES) and system complexity requires diverse methods and data. The position of the research in the middle of these two extremes lead to the integration of both quantitative and qualitative data in the research. Therefore, the data and information were collected through tools and techniques from both the social and natural sciences. Such a hybrid approach (Kwan 2004) can reveal new information which is not apparent from a single approach (Blythe 2012; Dong *et* *al.* 2010). There are both primary and secondary data which are both qualitative and quantitative in nature.

3.3.1. Primary data

The primary data were collected during the field study conducted from April to July 2013 in the selected PAs and VDCs. The field study comprised livestock censuses, household level interviews (questionnaire survey), focus group discussions (FGD), key informants interviews, participatory observation and vegetation sampling. After the confirmation of candidature and before data collection, the ethical approval for the research was obtained (approval no. H13REA001) from the University of Southern Queensland (USQ) Human Research Ethic Committee (HREC) to safeguard the participants of the research. Before starting survey or interview, paraticipants were were briefed about the purpose of the project, survey and interview, and prior consent was obtained as per the requirement of the University of Southern Queensland's research ethical guidelines.

3.3.1.1. Livestock census

During the field studies, the census of all types of livestock was done in the selected VDCs. This was necessary to determine the number of HHs having livestock and number of HHs practicing transhumance as this information was not available for study areas (Desta & Coppock 2004). This yielded the percentage of HHs involved in the transhumance and provided the information about the HHs which could be used to develop the survey. A livestock census form (Appendix A) was developed prior to the field visit. Two local research enumerators conducted the livestock census under my supervision following training on how to conduct the work. Each HH of the VDC was approached and asked the number of each type of livestock they owned and whether or not they practiced transhumance.

3.3.1.2. Households (HHs) survey

The HH survey was conducted to elicit information for a range of purposes. First, information obtained from the survey was used to explore and rank different reasons for practicing transhumance and to assess the contribution of transhumance systems to the HHs income. The HHs survey can be used to collect data pertaining to livestock husbandry and role of livestock husbandry to the economies of rural HHs (Nautiyal & Kaechele 2007). Second, perceptions and attitudes of herders towards PAs and CF were collected from the survey. Finally, perceptions of herders towards changes in key climatic variables and socio-economic information required for the vulnerability analysis to climate change were also obtained from survey. The draft survey questionnaire was developed based on review of the literature, previous experience of the researcher in the research areas (discipline, eographical region and culture) and supervisors' feedback. The draft questionnaire was refined based on expert consultation in Kathmandu. The irrelevant questions were removed and other necessary questions were added to the questionnaire even while conducting survey in the field study site (i.e. Khumjung of SNP).

A convenient (purposive) sampling method was used for the selection of households for the survey because only a subset of the populations were practising transhumance (Bernard 2005; Blythe 2012; Oteros-Rozas *et al.* 2012). The responses from the census were used to identify transhumant herders HHs. Furthermore, VDC secretaries and other local people were also consulted to identify such HHs. The herders who were surveyed were also asked about other HHs practising transhumance (snowball technique). Transhumant herders considered in this study were those who move their livestock at least 3 months in a year to the rangelands that are usually located in high altitude and were beyond the reaches of a single day for livestock grazing from the permanent settlements, i.e. they could not be accessed for livestock grazing from the home on a daily basis.

A total of 145 herders were surveyed using a semi-structured questionnaire (Appendix B). Only 37 herders from Khumjung were engaged in transhumance during the field study year and hence all of them were interviewed. Fifty-four herders were surveyed from each of Kalinchok and Majhigaun (Table 3.3). The oldest person of the HHs or family head was approached and interviewed. The general characteristics of the respondents of each site are given in (Appendix D). The interview was face to face and lasted for about 40 minutes per interviewee. In the context where a list of the respondents is not available and all respondents cannot read and write, face to face survey is the most effective survey method (Salant & Dillman 1994).

Table 3-3: Total number of HHs practicing transhumance and number of respondents

Site	VDC	Total no. of HHs*	No. of HHs with livestock**	Total no. of HH practicing transhumance**	Total no. of herders interviewed
SNP	Khumjung	551.0	176.0	37	37
GCA	Kalinchok	541.0	352.0	140	54
KNP	Majhigaun	787.0	636.0	111	54

* CBS (2012), ** Census and HHs survey

The semi-structured questionnaire (Appendix B) had 4 major sections. Section one focused on socio-economic information of respondents and his/her family including age, sex, education, family size, land holding, crop production and food sufficiency and household's incomes. Section 2 of the questionnaire focused on livestock related questions including types and number of each type of livestock, purpose of rearing, their production systems, feeding pattern, seasonal migration pattern, information on stopover and camping sites, and duration of stay at different sites. Section 3 of the questionnaire focused on herders' perceptions and attitudes, expectations and participations towards National Parks (NPs), Conservation Area (CA) and Community Forests (CFs). Section 4 covered questions related to herder's perceptions towards different bio-physical indicators and impacts of climate change to the transhumance system. The response of some questions were on a Likert scale from 1 (strongly agree) to 5 (strongly disagree) (Asah 2008; Freeman *et al.* 2012; Marshall *et al.* 2011) whereas the response of other questions were collected in the form of multiple choice, ranking multiple options, dichotomous (yes/no) and open ended responses.

In addition, there were questions in each section of the questionnaire which were later used for vulnerability analysis of transhumant herders to climate change. The information on socio-demographic profile, livelihood strategies, health facilities, social networks, food availability, and losses from climate-induced natural disasters were collected in a different section of the questionnaire inserting questions where they fitted better considering the sequence and flow of the questionnaire.

3.3.1.3. Focus group discussion

Two focus groups discussions (FGDs) were done in each site. FGD is an effective tool to obtain information from remote areas (Parajuli *et al.* 2013) and supplements information obtained from the survey and helps to cross validate them (Chaudhary & Bawa 2011; McElwee 2010). FGD has several advantages including gathering data quickly from groups of people at less cost and provides opportunities to clarify responses (Stewart *et al.* 2007). Furthermore, FGD are particularly important as participants get opportunities to interact, discuss and provide a common response (Kitzinger 1994; Wangui 2008). Herders were informed in advance about the venue and time of FGDs. The venues were selected so that it would be convenient to most of the herders. To maximize participation, FGDs were done when herders were relatively free (in the morning and evening time herders were busier milking and other activities). In SNP, the venues of FGDs were Khumjung School and Pheriche Kharka. In GCA, the FGD were conducted in Tarebhir village (junction of ward no. 6 and 7 of Kalinchok VDC) and Balodaya Secondary School. In KNP, one FGD was done in Ghoda Daune Patan and another in Majhigaun village.

A protocol (Appendix C) was developed to guide the FGDs based on a review of literatures, online search and expert consultations. At first, herders were asked to discuss the evolution of transhumance in the study area, the purpose of rearing each type of livestock, seasonal grazing areas and duration of grazing in each elevation. Second, herders discussed indigenous knowledge and cultural aspects of transhumance system.

Third, they discussed trends (or changes) in different aspects of transhumance (including the number of families practicing transhumance, herd size and composition, grazing areas and pattern, dependency on transhumance and involvement of the young generations) in comparison to four decades ago. Fixing temporal boundaries to study changes over time is, however, difficult and complex because actors and driving forces also change (Bürgi *et al.* 2004). Furthermore, there might be more than one variable responsible for such changes. The time frame must therefore capture changes in those variables. The reference of four decades was used in this study because from a review I concluded that most of the changes in Nepal (Table 3.4) which have potential to affect transhumance occurred after 1970. In addition, my experience from previous field trips to the mountainous areas of Nepal was that most herders involved in transhumance system were between 50 and 60 and they can recall change after 1970 in the systems and remember the oral history passed by elders (as most of them were at least 10 years old by 1970).

Finally, herders were asked to discuss the threats and opportunities of the transhumance system. The protocol was used flexibly depending on the conditions in the field, rather than as a rigid framework for the elicitation and organization of the information (Bryan *et al.* 2013). When participants reached common consensus after discussion, concluding remarks on each discussion topic were noted.

Table 3-4: Major change in Nepal after 1970

Area	Year	Change
Education	1971	New Education System Plan (1971), many schools established across country and school enrolment increased
Protected areas (PAs)	1973	National Parks and Wildlife Conservation Act (1973), different types of PAs were established following the passage of this act
Tourism	1970s	Tourism intensified, Nepal opened border for outsiders in 1950s, Mt. Everest first climbed in 1953, first ever organised mountain trekking was organised in 1966 and number of tourists visiting Nepal reach 100000 in 1976 (Nepal 2000; Thapa 2004)
Close of border	1988	Nepal and China agreed in 1959 to close border by 1988
Community Forests (CF)	1993	Concept of delivering forest to local people came after National Forestry Plan (1976) and Forest act (1993) legalised community forests
Labour migration	1990	Till early 1980s, labour migration was more or less restricted to India (Maharjan *et al.* 2012a). After multiparty democracy (1990), it became easier to get travel documents and visas. Furthermore, economic emergence of South-East Asian and Gulf countries combined with trade liberalisation in Nepal caused a rapid increase of labour migration and diversified destinations.
Civil war	1996	A decade of political conflict (1996-2006) started

3.3.1.4. Key informants interview

Both central and local level key personal involved in livestock, rangelands and forestry sectors were approached and consulted during the field study. At the central level, officers of the Department of National Parks and Wildlife Conservation (DNPWC) (related to PAs), Department of Forests (DoF) (related to CF), Department of Livestock Services (DoLS) (related to livestock production), Nepal Agricultural Research Council (NARC) (related to research on agriculture and livestock) were consulted. Policy level officers from Ministry of Forests and Soil Conservation (MoFSC), and Ministry of Agricultural Developmentwere also consulted in Kathmandu. At the local level, VDC secretaries, Chief Wardens of selected National

Parks, Chief of selected Conservation Area, CF executive members and officers of District Livestock Service Office and District Forest Office were interviewed.

Similarly, rangelands and livestock production experts of Nepal who represent universities and research institutions were consulted. Tribhuvan University and Kathmandu University are the main universities of Nepal and the Nepal Academy of Science and Technology (NAST) and NARC conducting research in science and agriculture were the obvious place to consult experts. Furthermore, the International Centre for Integrated Mountain Development (ICIMOD) has been conducting mountain focused research and development programmes in the Hindu Kush-Himalayan (HKH) region for which the rangelands and livestock are priority areas, therefore, experts from that organization were also consulted. These interviews and consultations were unstructured and the content of the interview varied depending upon the field of expertise of the key informants. These interview lasted for about half an hour ago and key information provided by interviewees were noted. These information were used to supplement the information obtained from survey and group discussion.

3.3.1.5. Participatory observation

Participatory observation of rangelands and herders' daily activities were done during the field study. The rangelands selected for the ecological study (comes in section 3.3.1.6) were visited with at least one herder. In the rangelands thus visited, some time was spent by walking around with herders who were asked to show if they have noticed any new plants in the rangelands, to identify toxic and unpalatable plants and how they differentiate overgrazed, grazed and non-grazed areas etc. Furthermore, we (me and my field assistants) stayed at least three days with herders in their *goth* (semi-permanent camping and stopping spot) at all sites while conducting vegetation sampling in the rangelands. This offered an opportunity to better interact with herders and to know their daily activities.

3.3.1.6. Sampling design and data collection for ecological study

Four rangelands in each of SNP and GCA and 5 rangelands in KNP were selected for ecological study. These rangelands were the grazing areas for the herders of selected VDCs. The selected rangelands were between 3982-4405m asl in SNP, 3350-3509m asl in GCA and 3002-3101m asl in KNP. All of them lie in the sub-alpine and alpine zones. Rangelands with open canopy were selected to exclude the effect of forest canopy on the vegetation. These rangelands were major grazing areas with gentle slopes compared to surrounding areas, were less risky from natural disasters such as landslides, rock fall, avalanches and flood, and therefore herders prefer to establish *goth* in these areas. It was confirmed from the consultation with herders that the selected rangelands were active with *goth* (semi-permanent stopping and camping spots) i.e. they were not abandoned, and grazed every year. The studied rangelands for each site are as follows:

SNP: Lapharma, Pheriche, Phulankarpo and above Dingboche
GCA: Kuri (left), Kuri (right), Tutan and Lamachaur
KNP: Daha Patan. Sugurbechne Patan, Ghodadaune Patan, Lampuchre Patan and Malika Patan

In each selected rangeland, one *goth* was taken as the reference point to study the grazing gradient and vegetation pattern. A horizontal transect of 800 m was established in a direction that captured the longest distance without crossing trenches, rivulets or jungle to minimise the effect of topography (Peper *et al.* 2011). Two 1m×1m plots were established at 5 metre distance (one in each left and right side) from the main transect at 25, 50, 100, 200, 400, 600 and 800 m respectively (Figure 3.2). This plot size was also used by previous scholars (Bhatta *et al.* 2012; Bhattarai & Upadhyay 2013; Bhattarai *et al.* 2004; Pokharel *et al.* 2007) and considered standard size to study species richness in Himalayan rangelands. This resulted in a total of 14 plots in each *goth*. The plots were further divided into four sub-plots of 0.25 m^2. The presence or absence of each species was recorded. Furthermore, the abundance of species present in the plots was recorded in 0 to 4 scales (0 for absence in all four sub-plots and 4 for presence in all subplots of a plot) (Aryal 2010; Shrestha & Vetaas 2009). This estimate is more appropriate for ordination analysis than collecting only presence or absence data for species from the plot (Shrestha & Vetaas 2009). Other environmental variables such as altitude (in m asl with the help of GPS), distance from *goth* (in metre using measuring tape), slope (in ° using clinometer), pH and moisture (using Takemura Electric Soil Tester) were also recorded for each plot. Percentage shrub cover, ground vegetation cover, rock cover and bare soil were visually estimated (Hendricks *et al.* 2005; Muñoz-Robles *et al.* 2012; Rochefort *et al.* 2013; Tocco *et al.* 2013; Zhang & Dong 2009). To minimise bias estimation, the estimations were made by three persons who were involved in the vegetation sampling for each of the studied plot and the averaged value was used.

The level of dung and trampling in each plot were estimated on scales of 0 to 4 (0 for absence in all four sub plots and 4 for presence in all subplots). Such categorical scales were used to record level of grazing (via dung), edaphic variables, and management variables by other scholars (Kahmen *et al.* 2005) too. The presence/absence of human disturbance and wildlife disturbance was also recorded for each plot. Plant identification was done following Polunin & Stainton (1984) and Stainton (1988) and scientific names are presented according to Press *et al.* (2000).

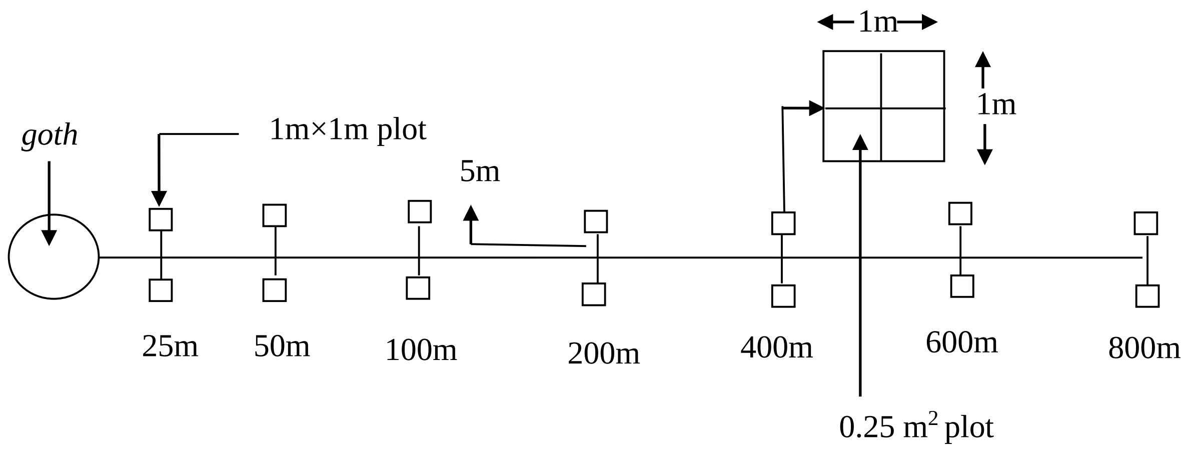

Figure 3-2: Sampling design for vegetation study along the transect from *goth*

3.3.2. Secondary data and information

3.3.2.1. Laws and policies

Policies and law of Nepal related to forest management, conservation and livestock production were collected. Among others, *Forest Act* (1993), *Community Forestry Guidelines* (2008), *National Parks and Wildlife Conservation Act* (1973), *National Park and Wildlife Conservation Regulation* (1974), *Mountain Park Regulation* (1980), *Khaptad National Park Regulation* (1988), *Conservaiton Area Management Rules* (1996), Tourism Policy (2009), Climate Change Policy (2011) and Rangeland Policy (2012) of GoN were collected.

3.3.2.2. Temperature and precipitation data

The temperature and rainfall data were collected from the department of Hydrology and Meteorology (DHM), Government of Nepal for the nearby stations. There were no recorded temperature and precipitation data available for the study areas due to the lack of stations. Therefore, the gridded data from Asian Precipitation Highly Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE) were used to analyse temperature and precipitation trends. The daily surface air temperature (2m) data from APHROTEMP (product: APHRO_MA_V1204 R1 with spatial resolution of 0.25°×0.25°) (Yasutomi *et al.* 2011) for the respective VDC were used for the analysis of temperature trends.

The APHRODITE precipitation data (product: APHRO_MA_V1003R1 with spatial resolution of 0.25°×0.25°) of the respective that are based on the observed precipitation data in conjunction with other precompiled data sets (Yatagai *et al.* 2012) were used. APHRODITE used the observed data from the maximum possible gauges available over Nepal to generate the gridded precipitation. Before analysing these data, the daily data obtained from the APHRODITE were converted to the monthly data and they were validated with the monthly temperature and rainfall data of the nearby stations. The approach where gridded data from APHRODITE are used after validating them in some grids for which station lies has been increasingly used by many scholars

(Agarwal *et al.* 2014; Duncan *et al.* 2013; Duncan *et al.* 2014; Madhura *et al.* 2014) in recent years.

3.3.2.3. Other information

Annual reports, brochures, leaflets and other publications related to livestock production, rangelands and forests were collected from respective PAs Office, District Livestock Service Office, District Forest Office and their line offices such as Departments and Ministries in Kathmandu and also from Central Bureau of Statistics (CBS), Kathmandu, Nepal.

3.4. Methods of data analysis

As this study is going to examine a social-ecological system, various kinds of data and information (primary and secondary, quantitative and qualitative, social and ecological) were collected using different tools and techniques. Different methods of analysis were applied in the study because no single method of analysis was suitable for data collected from mixed methods.

3.4.1. Document/content analysis

Policies and laws of Nepal collected during the field study were reviewed. Such a review can indicate a variety of contexts in which conflict with customary practices in resource use can occur (Beyene 2009). From the document analysis, the provisions of livestock grazing in PAs (NP and CA) and CF were extracted. Finally implications of these policies to the transhumance system were described. The information obtained from key informants interview, FGDs, observation and response of open ended questions of questionnaire survey were simply presented and described (Beyene 2009). Some information is presented separately (e.g. purpose of rearing each type of livestock, major changes in the systems) whereas other information is presented together with the results of survey where relevant.

3.4.2. Statistical analysis

Besides calculating descriptive statistics (such as mean, standard deviation), quantitative data were subject to the following statistical tests and analysis based on the nature data.

<u>Kruskal-Wallis test</u>

A non-parametric Kruskal-Wallis test was used to test how the level of dung and level of trampling differed at different distances from *goths* using IBM SPSS (IBM SPSS for Windows 2012) for each site. A non-parametric test was chosen as the response variables were not normally distributed and they were estimated for fixed distance categories.

t-test

Student t-test was done to examine whether the mean livestock unit (LU) differed between the herders whose family member/s were involved in tourism and not in Khumjung. Similarly, the t-test was used to check the differences in mean LU in non-migrants and migrants households in Kalinchok and Majhigaun. The normality of the response variable was checked before performing the test and the distribution was found to be normal.

Analysis of variance (ANOVA)

The difference in the mean species richness per plot (α-diversity) between sites and distances was tested by a two-way analysis of variance (ANOVA) using site and distance from a *goth* as factors. The distribution of the response variable (number of species per plot) was checked visually using graphs (histogram and Q-Q plot) before performing ANOVA and was found to be normally distributed.

Chi-square (χ2) test

A non-parametric χ^2 test was performed to test whether or not the proportions of herders agreeing (strongly agree + agree) and others (neither agree nor disagree + disagree + strongly disagree) differs for different schemes of forest management and conservation (CF, CA and NP). This test was also used to test whether the proportions of herders agreeing (strongly agree + agree) and others (neither agree nor disagree + disagree + strongly disagree) change in different biophysical indicators differed across sites. This test was performed using IBM SPSS (IBM SPSS for Windows 2012).

Regression

General linear regression was used to find the trends in temperature and rainfall. This is an easy technique to assess trends of climatological parameters and results from general linear regressions can be used for quantitative comparisons (Shrestha *et al.* 1999). The annual (January-December), winter (December-February), summer (March-May) and monsoon (June-September) (Nayava 1974; Shrestha & Aryal 2011) trends of maximum temperature and rainfall were obtained from this analysis.

Multivariate analysis

Ordination, the collective term for multivariate analysis (Bhattarai & Upadhyay 2013), was used to estimate the species turnover in the landscape (β-diversity) and to understand the vegetation-environment relationship. The β-diversity was calculated as the length of the gradient of the first axis in the Detrended Correspondence Analysis (DCA) (Hill & Gauch 1980) in ordination. The β-diversity helps the selection of methods for further ordination analysis and to identify variables in response to which species composition has mostly responded (Zuo *et al.* 2012). For ordination analysis, species and environmental data sets were prepared for each site (SNP-54 plots, GCA-54 plots, KNP-70 plots).

Detrended Correspondence Analysis was done in each data set to find the gradient length. The gradient length showed the magnitude of change in species composition along the first and second ordination axes (Zuo *et al.* 2012). The gradient length was >2.5, so a unimodal relationship was assumed between the response and predictor variables and the unimodel based methods; Canonical Correspondence Analysis (CCA) (Ter Braak 1986; Zhang 1998) was used in the subsequent analyses. To explore the overall environment vegetation relationship, CCA (Ter Braak 1986) was done for each data set. CCA is widely used and an effective ordination tools to examine the relationship between floristic composition and environmental factors (da Silva & Batalha 2008; He *et al.* 2007; Zuo *et al.* 2012). CCA was done in CANOCO with interspecies distances and hills scaling option. The significance of environmental variables in explaining variation in species data was tested using the Global Monte Carlo permutation test. In the analysis, rare species were down-weighted and only significant environmental variables were included. Furthermore, CCA with a Global Monte Carlo test was done with each environmental variable as explanatory variable one by one (Vanderpuye *et al.* 2002). The total inertia is the sum of eigenvalues for all axes and represents the measure of variation in the data set (Ter Braak 1986). The percentage of variance explained by each variable is expressed as the percentage of inertia obtained while that particular variable alone was used as explanatory variable to the total inertia while using all environmental variables as explanatory variables in CCA (McIntyre *et al.* 2003). This helps to understand the relative importance of variables to determine the species composition (Økland 1999).

The levels of dung and trampling and the percentage of bare soil represent grazing intensity (Zhang & Dong 2009). The data collected for these three variables were combined to get a single variable of grazing intensity. Principle Component Analysis (PCA) in CANOCO was used for variable reduction (Kahmen *et al.* 2005). The new variable was termed as ‘grazing’ in the subsequent analysis. PCA helps to reduce the number of variables and avoids multicollinearity. While creating such new variables by PCA, very low information associated with primary variables is lost because extracted axes explain most of the total variance contained in original variables. In PCA, the variability explained by individual axis gradually decreased starting from first axis and there can be a problem to decide how many ordination axes to present and interpret. Generally, the ordination axes explaining more than the average variability explained per axis are interpreted (Lepsˇ & Šmilauer 2003). This threshold value can be obtained by dividing the total variability (which is set to 1.0 in linear ordination methods in CANOCO by the total number of axes. In the PCA analysis consisting three variables (dung, trampling and bare soil), the total number of axes is equal to three. This means that using this approach, the axes explaining 0.33 (1/3) variability were to be considered for interpretation. According to this criteria, the plot scores of the first axis was only used to represent grazing because the eigen value of the first axis only was higher than 0.33 (0.987 and 0.01 for first and second axis in SNP, 0.962 and 0.028 for first and second axis in GCA, and 0.954 and 0.036 for first and second axis in KNP). The grazing thus obtained was plotted against distance from the *goth* to indicate whether the distance from the *goth* represents grazing gradient.

The ordination analysis was performed using *CANOCO for Windows*.

3.4.3. Vulnerability analysis

To understand how vulnerable transhumant herders are to climate change and how vulnerability differs across sites, an indicator based vulnerability analysis was done using data collected for different socio-economic variables from the survey. The Intergovernmental Panel on Climate Change (IPCC) third assessment report (2007) suggests that climate change vulnerability is a function of exposure, sensitivity, and adaptive capacity (IPCC 2001; Macchi 2011; Paavola 2008; Turner *et al.* 2003), or:
Vulnerability = f (Exposure, Sensitivity, Adaptive capacity).

More specifically, vulnerability is a positive function of the system's exposure and sensitivity and a negative function of the system's adaptive capacity (Ford & Smit 2004). These dimensions are dynamic and system specific (Macchi 2011; Smit & Pilifosova 2001).

Vulnerability assessments identify who and what are more or less sensitive to climate risks (Ford *et al.* 2010). It reflects both the social processes as well as material outcomes within the systems (Adger 2006). The challenges of vulnerability research are however, to develop robust and credible measures of vulnerability (Adger 2006) given the complexity of the systems being studied (Dougill *et al.* 2010). Indicator-based vulnerability assessment is useful for small geographical scales (Tonmoy & El-Zein 2013). This study adapts and applies the livelihood vulnerability index (LVI) (Hahn *et al.* 2009) and climate vulnerability index (CVI) (Pandey & Jha 2012) to assess and compare vulnerability of the transhumant herders in the study areas. Indicator based analysis in general and calculation of LVI and CVI in particular are flexible in the application of a set of indicators specific to a particular sector, areas and time. Indicators can be added, removed or replaced based on their relevancy to the study and practicality of getting data. Furthermore, primary as well as secondary and socio-economic as well as biophysical factors can be combined in this approach of vulnerability analysis. For remote areas such as considered in this study for which limited data exist for different variables or indicators, primary data can be easily generated by means of survey.

The LVI used in this study includes seven major components; socio-demographic profile (SDP), livelihood strategies (LS), social networks (SN), health (H), food (F), water (W) and natural disasters and climate variability (NDCV). Each component comprises several indicators or sub-components (Table 3.5) for which the data were collected during the survey including questions in different sections of the questionnaire. The indicators were developed based on a review of the literature and expert consultation (Acheampong *et al.* 2014). The criteria; relevancy, adequacy, ease, and data availability as suggested by Gbetibouo *et al.* (2010) were also employed while selecting indicators.

These were developed based on a review of the literature on each major component as well as considering the practicality of collecting data through household surveys. A balanced weighted average approach (Hahn *et al.* 2009; Pandey & Jha 2012; Sullivan *et al.* 2002) was used for calculating LVI where each sub-component contributes equally to the overall index even though each major component comprises different numbers of sub-components. Because all sub-components were not measured in a same scale, they were standardized as an index using equation 1.

$$indexS_p = \frac{S_{pa} - S_{min}}{S_{max} - S_{min}} \quad \text{..........................(1)}$$

Where S_p is the original sub-component for PA p, and S_{min} and S_{max} are the minimum and maximum values, respectively, for each sub-component among all three PAs. These minimum and maximum values were used to transform indicators into a standardized index.

The dependency ratio for each PA was obtained as the ratio of dependent (<16 years old + ≥60 years old) to working (16 to 59 years old) population (CBS 2012). For indicators that were measured in frequencies, such as the 'percent of households reporting conflicts over water resources in their community,' the minimum value was set at 0 and the maximum at 100.

The 'crop diversity index' and 'livelihood diversification index' were created from the inverse of the number of crops grown by the family, and the number of family income sources respectively. By taking the inverse, I assigned a higher value of 'crop diversity index' and 'livelihood diversification index' to the household growing few crops and having fewer income sources respectively. This is because an increase in these indicators was assumed to decrease the vulnerability, based on insights from previous studies which report that increasing crops and livelihood diversity reduces the vulnerability (Altieri & Nicholls 2013; Barrett *et al.* 2001). The maximum and minimum values for these indicators were also standardized following this logic and using the equation.

The indexed values for the indicators under climatic variability were also created using equation 1 where proportions of herders perceiving change in climatic variables (summer temperature, winter temperature, amount of total rainfall, amount of monsoon rainfall, amount of winter rainfall, amount of snowfall) for particular VDC were used (Pandey & Jha 2012). While, using proportions in standardisation, the minimum and maximum values were set as 0 and 100 respectively.

Table 3-5: Components and indicators used in vulnerability analysis

Components	**Indicators or sub-components**
Socio-demographic profile	Dependency ratio (working/non-working population)
	Percent of female headed HHs
	Percent of HHs where head of the HHs has not attended school
Livelihood strategies	Average livelihood diversification index
	Precent of HHs with family member working in a different community
	Percent of HHs solely dependent on agriculture and livestock as a source of income
Health	Average time to health facility (with MBBS doctor)
	Percent of HHs with family members with chronic illness?
	Percent of HHs going to *dhami-jhakri* (traditional witch doctors) during illness
Social networks	Percent of HHs received assistance from social networks
	Percent of HHs provided assistance to others
	Percent of HHs borrowing money from others
	Percent of HHs lending money to others
Food	Average number of months HHs struggle to find food
	Average crop diversity index
Water	Percent of HHs reporting water conflicts
	Percent of HHs that utilize natural water source (springs ponds, rivers)
	Percent of HHs that do not have a consistent water supply
Natural disasters	Average number of flood, drought, and cyclone in the past 5 years
	Percent of HHs that do not receive a warning before natural disasters
	Percent of HHs with an injury or death due to natural disasters in last 5 years
	Percent of HHs with an injury or death to their livestock as a result of natural disasters in the last 5 years
Climatic variability	Summer temperature perception index
	Winter temperature perception index
	Total rainfall perception index
	Summer months rainfall perception index
	Winter months rainfall perception index
	Snowfall perception index

After each sub-component was standardised, they were averaged using equation 2 to calculate the value of each major component.

$$M_p = \frac{\sum_{i=1}^{n} indexS_{pi}}{n} \qquad (2)$$

Where M_p is one of the seven major components for PA p, $indexS_{pi}$ represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components in each major component.

Once values for each of the seven major components for a PA were calculated, they were averaged using equation 3 to obtain the PA-level LVI.

$$LVIp = \frac{\sum_{i=1}^{7} W_{Mi} M_{pi}}{\sum_{i=1}^{7} W_{Mi}} \text{.......} (3)$$

This is expressed as equation 4;

$$LVI_p = \frac{W_{SDP}SDPp + W_{SN}SNp + W_{LS}LSp + W_H Hp + W_F Fp + W_W Wp + W_{NDCV}NDCVp}{W_{SDP} + W_{SN} + W_{LS} + W_H + W_F + W_W + W_{NDCV}} \text{.......} (4)$$

Where, LVI_p is the Livelihood Vulnerability Index for PA p which equals the weighted average of the seven major components. The weights of each major component, W_{Mi}, were determined by the number of sub-components that make up each major component and are included to ensure that all sub-components contribute equally to the overall LVI. Results are expressed as relative, rather than absolute, values ranging from 0 (least vulnerable) to 1 (most vulnerable) and are useful for cross comparison of intra- and inter-group vulnerability and to identify the most and least vulnerable groups of transhumant herders.

The index for exposure (*Exp*) (equation 5), sensitivity (*Sen*) (equation 6) and adaptive capacity (*Ada.cap*) (equation 7) were calculated as follows.

$$Exp = \frac{W_{e1}ND + W_{e2}CV}{W_{e1} + W_{e2}} \text{.......} (5)$$

Where, W_{e1} and W_{e2} are the weight for natural disasters and climatic variability respectively. It was equal to the number of sub-components.

$$Sen = \frac{W_{S1}H + W_{S2}F + W_{S3}W}{W_{S1} + W_{S2} + W_{S3}} \text{.......} (6)$$

Where, W_{s1}, W_{s2} and W_{s3} are the weight for major components health, food and water respectively.

$$Add.cap = \frac{W_{a1}SD + W_{a2}LS + W_{a3}SN}{W_{a1} + W_{a2} + W_{a3}} \text{.......} (7)$$

Where, W_{a1}, W_{a2}, W_{a3} are the weight for socio-demographic profile, livelihood strategies and social networks respectively.

The indexed values for exposure, sensitivity and adaptive capacity were combined for the weightage of CVI (equation 8) as follow.

$$CVI_p = 1 - I\left\{\frac{N_1 Exp - N_2 Ada.cap}{N_1 + N_2}\right\} I * \{\frac{1}{Sen}\} \text{.......} (8)$$

Ni is the number of major components in the i_{th} dimensions of vulnerability

3.5. Conclusions

To capture variation across mountainous region of Nepal and generalise findings with a broader perspective, three study sites were selected representing Eastern, Central and far-Western mountains of Nepal. The major selection criteria were the existence of transhumance systems and the presence of PAs and/or CFs. The description of selected sites showed that transhumance is one of the important livelihood activities of the people in those areas (see next chapter also). Objectives to be investigated were multidisciplinary in nature so that a hybrid research approach was used. Both the primary and secondary data were collected using research tools from social and natural sciences. Data related to livestock, rangelands and transhumant herders, which are three major components of the transhumance system, were collected. Primary data were collected by questionnaire survey, FGDs, key informants interview, participatory observation and vegetation sampling. Data analysis techniques include content analysis for laws and policies, and different statistical analysis depending upon the nature of data including Kruskal-Wallis test, t-test, general linear regression, ANOVA and ordination (multivariate analysis). For vulnerability analysis to climate change, the IPCC framework that examines vulnerability as a function of exposure, sensitivity and adaptive capacity was used. The data were grouped and analysed in two ways; in most cases, it was done by site wise (Khumjung/SNP, Kalinchok/GCA and Majhigaun/KNP) and in some cases (section 6.3) it was based on forest management and conservation regimes (i.e. CF, CA and NP).

Chapter 4 : Contemporary transhumance systems, socio-economy and culture

4.1. Introduction

Following the methods of data collection and analysis presented in chapter 3, the purposes of this chapter are to present the current status of transhumance systems and their socio-economic and cultural significances in the study areas. To describe the current status of transhumance system, percentage of households (HHs) currently involved in transhumance, livestock holding and composition, spatio-temporal pattern of seasonal grazing and reasons for seasonal movement (transhumance) are presented. Socio-economic and cultural significances are demonstrated in terms of contribution of transhumance livestock production to the HHs income, its interdependency with agricultural production and a variety of traditional and cultural norms related to livestock.

4.2. Status of transhumance systems

4.2.1. Livestock holding and composition

Out of 551 HHs in Khumjung, 176 own some kind of livestock, of which 21% (37) practice transhumance. The total number of livestock in Khumjung was 1556 equivalent to 1296.7 livestock units (LU). In Kalinchok, 352 HHs out of 541 own livestock and about 40% (140) of them practice transhumance. The total number of livestock in Kalinchok was 2740 accounting for 1681 LU. In Majhigaun, there were 787 HHs, of which 636 owned livestock and 17.5% (111) of those practice transhumance. The total number of livestock in Majhigaun was 5704 which is equivalent to 3478.9 LU. The herd size was largest for Khumjung (7.4 LU/HH) and smallest for Kalinchok (4.8 LU/HH) (Figure 4.1, Table 4.1).

Table 4-1: Livestock holding pattern in study areas

Vilage Development Committee (VDC)	Total no. of livestock	LU*	LU/HH (HHs with livestock)
Khumjung	1556.0	1296.7	7.4
Kalinchok	2740.0	1681.1	4.8
Majhigaun	5704.0	3478.9	5.5

Source: Census (2013), * Total livestock unit (LU) was calculated following Thapa and Poudel (2000) and Rasaily and Ting (2012) where 1 LU = 1 buffalo =1.2 cow = 4 goats = 5 sheep = 2 calves. Yak/nak, *chauri/jokpyo* and horses were assumed equal to cow while calculating LU.

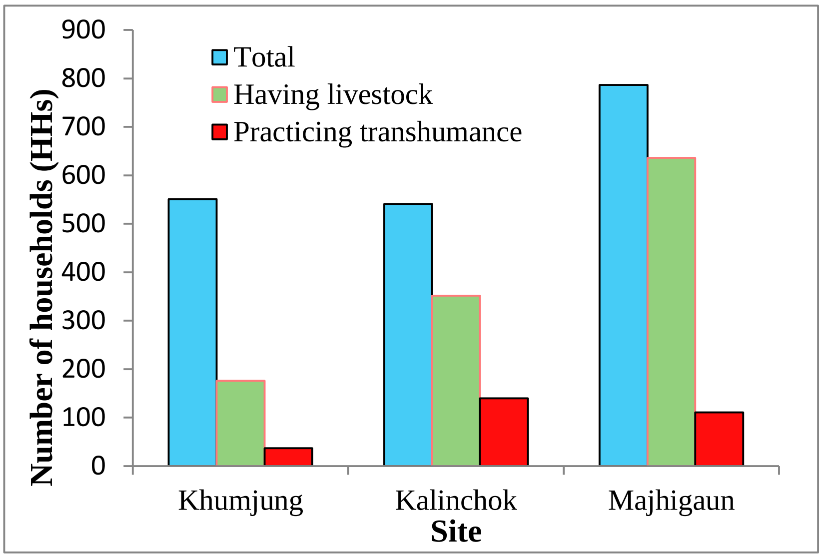

Figure 4-1: Total number of households (HHs), number of HHs having livestock and HHs practicing transhumance

In addition to the herd size, the type of livestock in the herd is also an important aspect of transhumance. In Khumjng, yak/nak (*Bos grunniens*) was the dominant livestock types followed by *charui/jokpyo* (hybrid of yak/nak (*B. grunniens*) and cow/bull (*Bos taurus*) and vice-versa). Other livestock type consisted of cow/bull (*B. taurus*) and horses (*Equus caballus*). In Kalinchok, cow/bull was the dominant livestock type; with others being buffalo (*Bos bubalis*), goat (*Capra hircus*) and *chauri/jokpyo*. In Majhigaun, cow/bull (*B. taurus*) was the dominant livestock and remaining were goats (*C. hircus*), buffaloes (*B. bubalis*) and horses (*E. caballus*) (Figure 4.2, Figure 4.3).

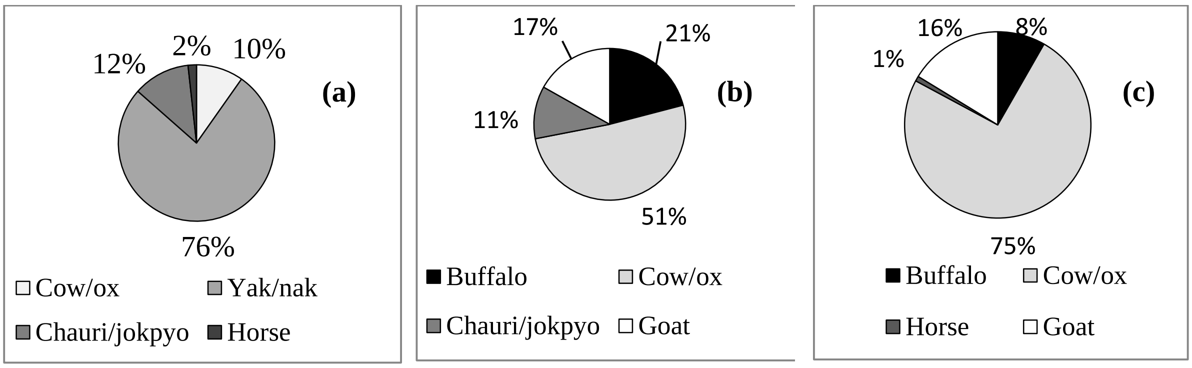

Figure 4-2: Composition of livestock in the study areas; Khumjung (a), Kalinchok (b) and Majhigaun (c) by number of livestock

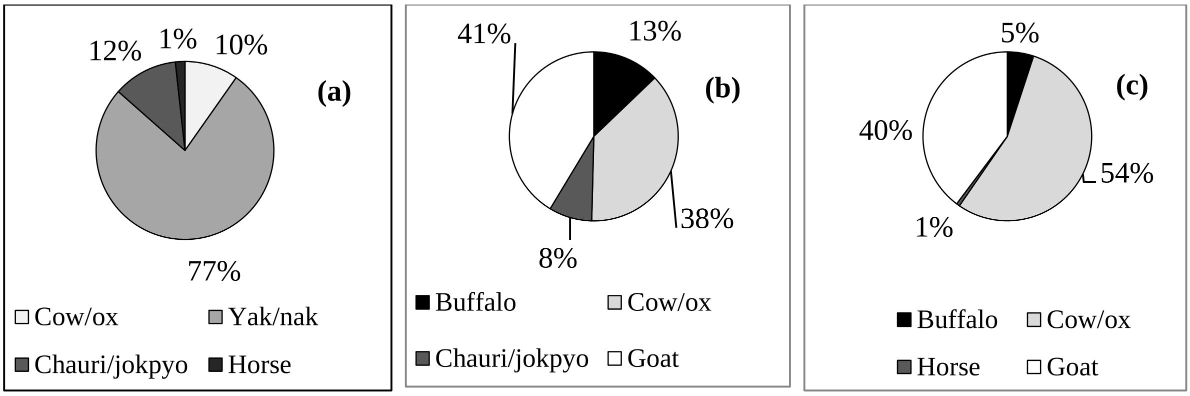

Figure 4-3: Composition of livestock in the study areas; Khumjung (a), Kalinchok (b) and Majhigaun (c) by proportion of total livestock units (LU)

Table 4-2: Types of livestock by household

Livestock type	Percentage of households having each type of livestock		
	Khumjung (n=37)	**Kalinchok (n=54)**	**Majhigaun (n=54)**
Yaks/naks	100.0	0.0	0.0
Chauris/jokpyos	54.1	18.5	0.0
Cows/bulls (oxen)	35.1	87.0	100.0
Horses	10.8	0.0	18.5
Buffaloes	0.0	46.3	88.9
Goat	0.0	63.0	68.5

Source: Survey (2013)

The households in the study areas had mixed different livestock in the herd (Table 4.2). The main reason for mixing different livestock in a herd was to get multiple benefits (Table 4.3). Yaks/naks were found only in Khumjung where they were used as a means of transportation. They were also crossed with cow/bull to produce *chauri/jokpyo*. *Chauri* was reared primarily for milk and dairy products in Khumjung. *Jokpyos* were used as a means of transportation similar to yaks. The dung of yak/naks and *chauri/jokpyo* was used as fertilizer or manure. Some people collect dung to make dung cake which was used as fuel to cook food and for space heating. The purposes of rearing *chauries/jokpyos* in Kalinchok were similar to that of Khumjung. However, the dairy products were mainly exported outside the Village Development Committee (VDC).

Cows/oxen were found in all study areas. However, the purpose of rearing was different across sites. In Khumjung, few cows and bulls were combined with other livestock to cross with yaks/naks to produce *chauri/jokpyo*. However, in Kalinchok and Majhigaun, cows were reared for milk and manure whereas oxen were kept for draft power to plough agricultural fields. The purpose of rearing buffaloes was for milk and manure. The main purpose of rearing goats was for meat. In the past, these goats were shorn together with sheep for wool. However, they ceased this practice in recent times. Few HHs in Khumjung and Majhigaun kept horses, and in few numbers. In

Khumjung, horses were used as a means of transportation to carry sick persons. In Majhigaun, horses were used to carry the bride and bride–groom during wedding ceremonies and some local elites also use them as a means of transportation.

Table 4-3: Purpose of rearing different types of livestock in the study areas; n.a. = not applicable

Livestock	**Purpose of livestock**		
	Khumjung	**Kalinchok**	**Majhigaun**
Yak/nak	Means of transport, manure, milk, fuel (dung cake), reproduction (cross with cow/bull to produce *chauri/jokpyo*), wool, tail (*chamar*), hide (used as mat)	n.a.	n.a.
Chauri/Jokpyo	*Chauri* for manure, milk and milk products (yoghurt, butter, ghee) *jokpyo* for meat, manure and transportation, wool, tail (*chamar*), hide (used as mat)	*Chauri* for milk and milk products (*chhurpi*-hardened cheese, yoghurt, butter, ghee) and manure, the number of *jokpyo* are very few and used to carry goods, tail (*chamar*), hide (used as mat)	n.a.
Cow/ox	Primarily for reproduction (seed) to cross with yak/nak to produce *chauri/jokpyo* and for manure	Cow for manure, milk and to produce calves, ox for draft power (ploughing field), manure and threshing	Cow for manure, milk and to produce calves, ox for draft power (ploughing field), manure and threshing
Buffaloes	n.a.	Milk and milk products, manure	Milk and milk products, manure
Goat	n.a.	Meat, manure	Meat, manure, wool
Horse	Very few in number and used as means of transportation	n.a.	Means of transportation to carry sick persons and bride and bridegroom

Source: FGD (2013)

4.2.2. Spatio-temporal pattern of grazing

Transhumant herders in all study areas move their livestock seasonally. The numbers of stopping and camping points vary from one site to another (Figure 4.4). Herders from Khumjung use a large number of stopping and camping points and move long distances compared to those from Kalinchok and Majhigaun. This has reduced the length of the stay at each point in Khumjung. The brief description of the complete annual cycle of livestock movement for each site is given below.

4.2.2.1. Khumjung

The herders of Khumjung keep their livestock in the village from early October when they complete harvesting of major crops such as potato, buckwheat and barley. They graze their cattle in the harvested field, fallow land and forests near to, and below the village. At peak winter season (i.e. in December and January), they move their livestock slightly above the village where they feed hay collected and stored in the *goth* (temporary camping and stopping camps) the previous summer season. At the end of the winter season, they bring their livestock to the village and remain there for about three months (till mid-April). They feed buckwheat and barley straw stored in the village at this time. Some herders take their cattle further down to the village. After mid-April, all livestock are moved upward from the village to the grazing areas at intermediate elevation. At the beginning, grazing is supplemented with hay. Hay feeding is gradually replaced by grazing because grasses grow in these rangelands in May. They spend about two months (mid-April to mid-June) in these intermediate elevation rangelands before reaching the highest altitude rangelands sometime in mid-June. They stay there for about two months (mid-June to mid-August) in peak summer season. They are again returned to the rangelands of intermediate elevation in mid-August and stay there till the end of September before reaching their village in October.

All livestock are moved from the village in the summer season because grazing is completely restricted near settlements. But, all HHs do not send herders with livestock in summer grazing areas. HHs having large herd sizes send a family member as a herder whereas those HHs having few livestock combine with each other and send herders in rotation or merge their livestock with the HHs having large herd sizes. The HHs sending their livestock with others assist the herders' family to perform other agricultural tasks.

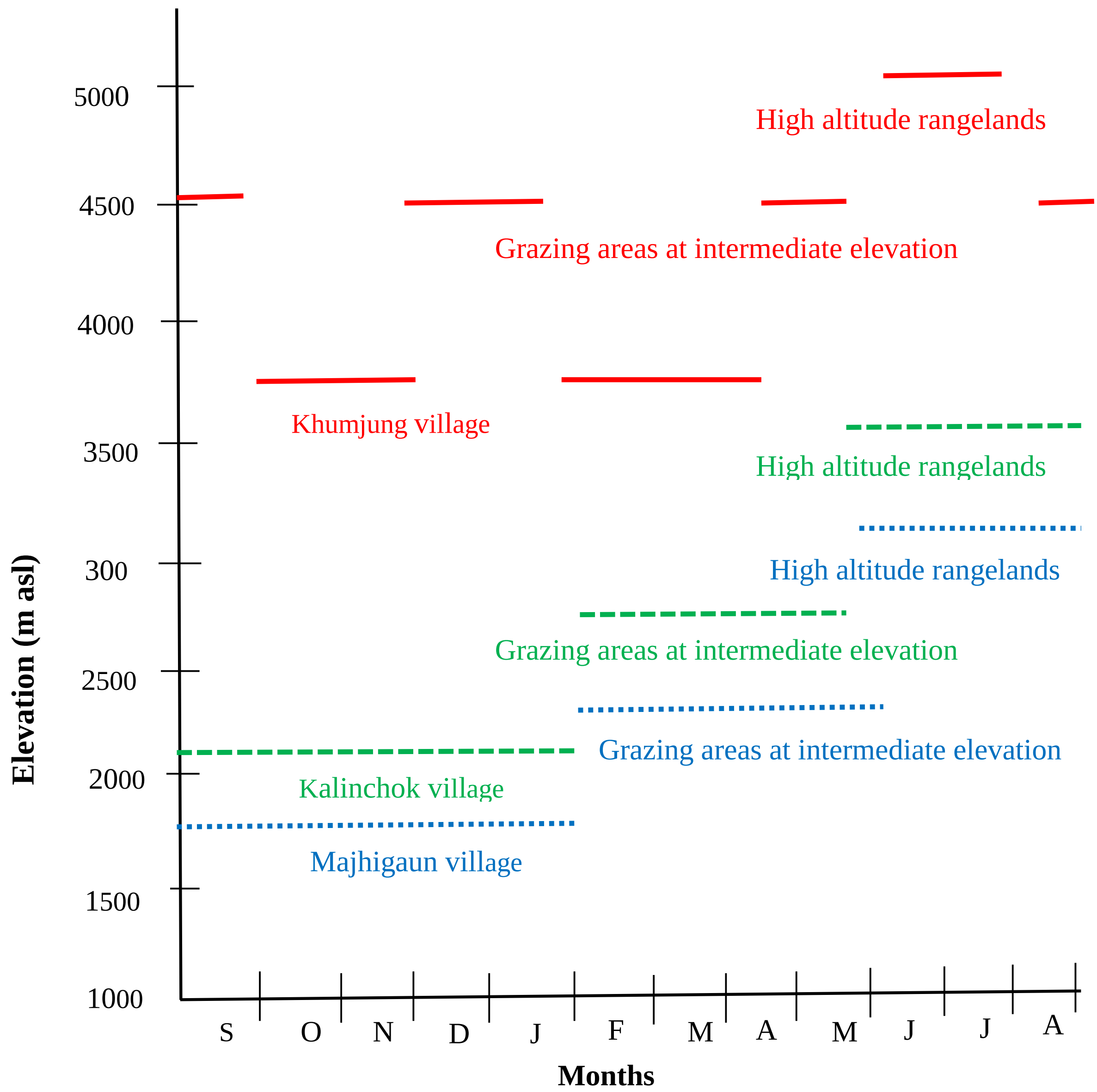

Figure 4-4: Spatio-temporal pattern of livestock movement in the study areas; ▬▬ = Khumjung (in SNP), ‒ ‒ ‒ = Kalinchok (in GCA) and ······ = Majhigaun (in KNP)

4.2.2.2. Kalinchok

From September through January, the herders of Kalinchok keep their livestock in the village at the lower elevation. During this time, they graze their livestock in the harvested field, fallow land, and feed on wheat and maize straw. They also graze near river banks, creeks and small forest patches below the settlement. In early February, they move their livestock to their second home located at the upper part of the village. They graze their livestock in the harvested field and fallow land for a few days, and then they graze livestock in the community forest (CF) (Kalinchok CF) for about three months (i.e. till mid-May). The CF lies just above Kalinchok village. After mid-May, all livestock are moved to high altitude rangelands where they are grazed till the end of August before being brought back to the village in early September. There were eight families or HHs in Kalinchok who were involved in *chauri* rearing during the field study. The *chauri* rearing was completely based on grazing and they moved to different grazing areas throughout the year. They use forests of neighbouring VDCs in the lower elevation in the winter season and the distant rangelands at high elevation in the summer season. However, the majority of herders rearing cattle and buffaloes move to high altitude rangelands only in the summer season, and in remaining seasons, they graze their livestock in the forest near the village or in the fallow land.

Table 4-4: Major grazing areas at different elevation

Elevation	**Main grazing areas**		
	Khumjung	**Kalinchok**	**Majhigaun**
Low elevation	Harvested field, fallow land and forests near to the Khumjung, Khunde and Phortse settlement and fallow land surrounding these village	Harvested field, fallow land, river bank and other forest patches near major settlements of Kalinchok (Tarebhir, Dhusikharka, Begumpa, Benpa, Mukcha, Golmagaun	Harvested field, fallow land, river bank, CF and other forest patches near settlements such as Meltadi, Darugaun, Dhunkhet, Khatribada, Netakatiya, Silkabada
Intermediate elevation	Rangelands at Pangboche, Rala, Pheriche, Jampur, Dingboche, Phulankarpo, Kyubo, Machherma, Luja, Thore, Lopharma, Dole, Khana	Agricultural land and forests near village, Kalinchok CF	Agricultural land and forests (in BZ of KNP) near Chhanna, Lokhada, Bamili, Khopdi and Kotalla
High elevation	Thokla, Chola, Pipre, Dhusum, Gokyo, Thangnak, Chharchun, Phan, Chhamtyan, Nha, Chhum	Kuri, Tutan, Baghkhor, Chaurikhor, Merekapa, Aahale, Mehale, Hile, and Lamachaur	Daha patan. Sugurbechne patan, Ghodadaune patan, Chhedi patan, Tribeni patan, Lampuchre and Malika patan

Source: FGD (2013)

4.2.2.3. Majhigaun

In Majhigaun, herders kept their livestock in the village from September to January. In that period, livestock were grazed in harvested fields, community forests, river banks, creeks and small forests patches and sloping lands. They supplement grazing by feeding straw (rice, maize, and wheat). About fifty percent of the herders continue the same practice till the end of May whereas the other 50% move their livestock to the Buffer Zone (BZ) forests above the village in February and stay there till the end of May. From December to May, herders supplement grazing by lopping fodder trees. At the end of May, herders go to the Khaptad National Park (KNP) office to pay grazing fees and collect written permission (locally called *purji*) to graze their livestock in the KNP during summer season. When KNP opens rangelands for grazing, all transhumant herders bring their livestock to the KNP. This generally begins in June and continues until the end of August. When KNP announce closing of grazing inside KNP, usually at the end of August, all herders bring back their livestock to the village. As KNP and summer grazing areas inside it lie at the junction of four Districts

(Bajhang, Bajura, Doti and Accham), herders from all these adjoining Districts bring their livestock to the rangelands inside KNP.

4.2.3. Deciding date for movement

Different factors were applicable to fixing dates for livestock movement from village to grazing areas, and from one grazing area to another. In Khumjung, it was based on the decision of traditional village leaders called *nawa,* however, in Kalinchok and Majhigaun the most important factor was the opening and closing of Community Forests (CFs), Conservation Area (CA) and National Park (NP) for livestock grazing. *Mountain National Park Regulation* (1980) to allow herders inhabiting SNP to graze their livestock in the park area. The opening and closing is irrelevant to herders of Khumjung as this VDC lies inside SNP.

The *nawa* system (locally called *nawa pratha* or *di*) in Khumjung was a traditional inherited system. In this system, *nawa* is elected each year by a village meeting in each village (usually a big settlement in the area) in rotation among the households of the same village. *Nawa* demarcates the area (fix some points in four directions) around the settlement and agricultural land where villagers cannot keep their livestock during the crop growing period. *Nawa* announce the date to move (chase) livestock from the designated area and to bring back their livestock to the village. *Nawa* generally fix the date just before cropping time to remove livestock from the village and just after harvesting time to bring livestock back to the village. If any livestock comes to the village for more than 24 hrs in this period, the *nawa* fix a punishment (fine) to the owner of that livestock.

Most winter grazing areas of the Kalinchok VDC were within the CF, so access to this grazing was related to the opening of the CF for grazing. The areas including summer grazing areas are currently within Gaurishankar Conservation Area (GCA). GCA has not completely dissolved CFs and planned to change them to Conservation Area Management Committees (CAMCs) which are the functional unit of the CA. Now, the opening of the grazing areas is done by the CAMC, however, they are not yet fully functional and most of the herders know CF and are not aware of CAMC. The opening of summer grazing areas within GCA is made by the executive committee of CAMC whereby they are discussed with the neighbour, remember the dates from the previous year and also look for the grass conditions in the rangelands.

In Majhigaun, the movement of the livestock is mainly related to the opening of the rangelands inside KNP for the livestock grazing by the KNP authorities. KNP announces the date when villagers from the surrounding villages can bring their livestock after getting *purji* i.e. written permission to graze livestock. KNP opens rangelands for about 4 months (from May to August) where herders graze their livestock after paying fees specified by the Park. The Park authority considers the grass condition in the grazing lands and dates from previous years to open the park area for grazing.

4.2.4. Reason for seasonal movement

There are many reasons why herders move their livestock seasonally. The reasons behind seasonal movement were identified from the literature, and their applicability in the Nepalese context was verified in consultation with subject experts in Kathmandu. Thus identified and selected, reasons were included in the questionnaire and administered through the household survey. The level of agreement of transhumant herders on different reasons why they move livestock from one grazing areas to other was collected and arranged on a scale from strongly disagree (-2) to strongly agree (+2). The weighted scores for each of the reasons was calculated and ranked.

The herders of all study areas ranked that the first reason for movement was in search of grazing resources. It was followed by seeking appropriate temperature in Khumjung, whereas to avoid the overgrazing was ranked second in Kalinchok and Majhigaun. The second most cited reason in Khumjung was placed in 3rd position in Kalinchok and Majhigaun (Table 4.5).

Table 4-5: Weighted scores and ranks for different reasons of transhumance in the study areas. Data were collected on a scale from -2 to 2, where -2= strongly disagree, -1= disagree, 0= neutral, 1= agree, and 2= strongly agree

Reasons for transhumance	**Average weighted score and rank**					
	Khumjung		**Kalinchok**		**Majhigaun**	
	Score	**Rank**	**Score**	**Rank**	**Score**	**Rank**
In search of grazing resources	1.73	I	1.80	I	1.76	I
To be safe from cold and hot (seeking appropriate temperature)	1.49	II	0.87	III	0.59	III
To avoid overgrazing in the grazing land	1.14	III	1.37	II	1.17	II
In search of water	-0.03	IV	0.74	IV	-1.70	V
To match the timing of medicinal plant collection	-0.38	V	-0.72	VI	-0.93	IV
To make sale of livestock products easier	-0.51	VI	-0.67	V	-1.74	VI

Source: Survey (2013)

In Khumjung, the date for moving livestock from village to the rangelands was fixed by the village leader (locally called *nawa*), elected by village assembly. The main considerations by *nawa* in deciding dates were planting and harvesting time of crops, grass condition in the rangelands, discussion with the neighbours and festive time. Unlike in Khumjung, the movement of livestock to and from the summer grazing areas in Kalinchok was associated with the opening and closing of CF and GCA area for grazing. In Majhigaun, it was mainly related to the decisions of the KNP authority. Other factors herders consider while deciding dates for livestock movements within summer grazing areas were the condition of the grass in the rangelands, remembering dates from the previous year, discussion with neighbours, dates of festivals and group decisions of herders.

4.3. Socio-economic and cultural significances of transhumance

4.3.1. Livestock production and herders household economy

There were diversified sources of income in herder HHs. All surveyed herders had income from agriculture and livestock (Table 4.6). In addition to the agriculture and livestock production, tourism was a source of income for 73% herder HHs. In Kalinchok, remittance was received by about one third of herder HHs, whereas in Majhigaun more than 55% of herder's HHs earn cash from seasonal migration of family member to Indian cities.

Table 4-6: Number of households (HHs) by income sources; figure in the parenthesis indicates percentage of HHs

S.N.	Income source	Number of HHs		
		Khumjung (n=37)	Kalinchok (n=54)	Majhigaun (n=54)
1	Agriculture	37 (100)	54 (100)	54 (100)
2	Livestock	37 (100)	54 (100)	54 (100)
3	Tourism	27 (73)	6 (11.1)	0 (0)
4	Portering/*jyaladari*	21 (56.8)	11 (20.4)	24 (44.4)
5	Job	3 (8.1)	14 (25.9)	24 (44.4)
6	Remittance (including income from seasonal migration to India)	0 (0)	17 (31.5)	30 (55.5)
7	NTFPs	0 (0)	0 (0)	3 (5.5)

Source: Survey (2013)

The average HHs income was highest for the transhumant herders of Khumjung and Lowest for Majhigaun. In Khumjung, livestock production had the highest contribution to the herder HHs economy. The second highest contribution was from tourism and agriculture was in third position. The largest figure for livestock contribution in Khumjung is also somewhat related to tourism because livestock such as yaks and *jokpyos* are basically used as means of transportation to carry goods and luggage of tourists and tourism related business. In Kalinchok and Majhigaun, the contribution from livestock production was second to agriculture whereas remittance was in third position in contributing to the herders HHs economy (Table 4.7). Though the contribution of remittance was in third position in Kalinchok and Majhigaun, there was difference in the destinations where people usually migrate to earn money. The youths of Kalinchok have been working mainly in Gulf countries (United Arab

Emirates, Dubai, Quatar, Malaysia) and South Korea. About 1/3rd of the HHs in Kalinchok had at least one family member working in these countries. However, for the people of Majhigaun, Indian cities (Delhi, Mumbai and Kolkata) are major destinations. After planting major crops, most of the youths (mainly male) move to Indian cities and come back during harvesting time which almost coincides with the festive seasons.

Table 4-7: Average household (HH) income from different income sources. Figure in the parenthesis represent percentage of HHs income; according to 18th March 2015 conversion rate 1$ = 100.01NRs

S.N.	Income source	Average HHs income (NRs/yr)		
		Khumjung	Kalinchok	Majhigaun
1	Livestock	107162 (37.8)	79741 (31.2)	49352 (25.5)
2	Agriculture	51784 (18.3)	87907 (34.3)	54444 (28.1)
3	Tourism	65541 (23.1)	556 (0.2)	0 (0.0)
4	Portering/*jyaladhari*	45270 (16.0)	12963 (5.1)	21944 (11.3)
5	Job	13513 (4.8)	23333 (9.1)	30371 (15.7)
6	Remittance (including income from seasonal migration to India)	0 (0.0)	51481 (20.1)	35833 (18.5)
7	NTFPs	0 (0.0)	0 (0.0)	1759 (0.9)
	Total	283270 (100.0)	255982 (100.0)	193703 (100.0)

Source: Survey (2013)

4.3.2. Crop production and transhumance

Crop and livestock production were integrated livelihood activities in all study areas. Livestock were the only source of manure, with no availability of chemical/organic fertilizers. Crop residues were the basis of the diet for livestock in the grass deficit winter season and fallow lands after harvesting crops were used to graze livestock in the winter season. This had mutual benefits; livestock had feed, and at the same time the fallow lands were enriched by nutrients from livestock excreta (dung) and urine. In addition, the livestock were for ploughing and preparing agricultural land. In Khumjung, yak or *jokpyo* were used for this purpose, however, this was a recent shift from human power, in response to labour shortages. In Kalinchok and Majhigaun, the use of oxen as draft power to plough and prepare fields was a long-standing and common practice. During focus group discussions (FGDs), people of Kalinchok and Majhigaun highlighted that they cannot imagine agricultural practice in the absence of livestock.

4.3.3. Indigenous knowledge, culture and transhumance

A transhumance system is not exclusively an economic activity in study areas and holds traditional knowledge, institutions and practices and also represents a socio-cultural tradition. Movement of livestock at different altitudes was the recurrent feature of traditional grazing in all study areas. Herders have developed some practices that help them to define movement dates and migratory routes, and they had traditional classification of grazing ownership over rangelands used in the summer season. The *nawa pratha* (as discussed in 4.2.3), a historically and locally evolved institution was active in Khumjung in which villagers elect *nawas* from the village meeting. The elected *nawas* were responsible to define departure and arrival dates of livestock in the village. They were also responsible for control of and regulating of access to grazing areas, enforcing well defined and mutually agreed upon rights and rules. The elected *nawas* were responsible for regulating livestock management, agriculture production, maintaining law and order and resolving conflict in the society.

In Kalinchok, local people have divided grazing ownership of summer grazing areas (for use) in such a way that the distance between grazing areas and the settlements is minimal for all users as much as possible. They also consider nature of topography, water availability, aspects of the mountains, sunlight and prevalence of insects and pests. Herders in the same community usually negotiate with each other or depend on the Conservation Area Management Committee’s (CAMC) decision to mitigate conflict arising from sharing rangelands.

In Majhigaun, the date to bring and remove livestock in the Park was defined by KNP authority (4.2.3), but the herders from the four adjoining Districts have fixed areas where the herders of each District can graze their livestock. The distance from settlement to grazing areas was considered in fixing the grazing ownership of rangelands among herders from four Districts so that they could graze in the rangelands that are nearest to the village. Even within the rangelands allocated for a particular district, herders have delimited grazing areas and defined user rights which were traditionally inherited through matrilineal relations. Herders mentioned that productivity of the rangelands, distribution of plant species and their palatability were considered when dividing rangelands for grazing. This showed that traditional knowledge and institutions were important in defining movement date, route and grazing areas.

Additionally, herders had locally developed practices and beliefs related to transhumance. In Khumjung, there is an indigenous practice for cross-reproduction between yak/nak and cow/bull to produce *chauri/jokpyo*, a trait that can sustain the temperature ranges that yak/nak and cow/bull cannot tolerate. Herders castrate two to three year-old yaks to avoid being violent and to make handling easier. Herders from Khumjung also mentioned that they had trained their livestock to react to a herder’s call (particular words and sounds of a herder) which was very useful to gather livestock in *goths* in the evening and direct the herd towards water sources. Herders of Majhigaun have trained their herd to listen and react to the sound of a bell which they put on the neck of old and experienced livestock because they believe that old and experienced livestock can keep the herd together. Herders use sound emitting from the bell to locate the herd. Furthermore, herders use salts to bait goat. Herders mentioned that these practices help them make efficient use of the labour force in herd management. They further mentioned that they use different species of plants to classify rangelands as degraded or non-degraded. The loss of key forage species and appearance of less palatable species in the rangelands were used as indicators of degradation.

The transhumance system would also represent the culture of local people and it was a socio-cultural tradition in the study areas. Khumjung is dominated by Sherpa people who follow Buddhism and do not slaughter livestock. As hunting or poaching is religiously prevented, it might have an important role in the conservation of endangered wildlife such as snow leopard and musk deer. In the Sherpa society of Khumjung, the number of livestock (mainly yaks) would show wealth and class of family in the past, however this basis of wealth status has been camouflaged due to tourism.

Herders from Kalinchok mentioned that there was some differences in the livestock owned by households by ethnic groups. According to them, Sherpa and Tamang were engaged in *chauri* rearing whereas large flocks of goats/sheep were owned by Newar (Shrestha). People belonging to other communities such as Thami, Pakhrin and Brahmin (called upper caste) kept buffaloes and cows/oxen. They mentioned that the transhumance was inherited from the previous generations and this had evolved as their culture. They further highlighted that the livestock production (which includes transhumance) has made the area liveable because it has made agricultural production possible in the area.

Herders from Majhigaun reported that livestock types owned by family differs with the caste and represent the socio-economic status of the family to some extent. Generally the family of lower caste own low productive animals and they usually don't rear lactating buffaloes or cattle because they have little land and low stock of fodder trees and agriculture residue (rice and wheat straw) which were fed to the livestock in the winter season. The family owning lactating buffaloes and horses are generally wealthy and prestigious among others. All herders in Majhigaun follow Hinduism. Cows are compared to Aditi (mother of gods) and they are never slaughtered. Furthermore, slaughtering any kinds of female animals is not considered good in this society. As in other Hindu societies, Hindu people of Kalinchok and Majhigaun sacrifice many male livestock (basically he-goat and he-buffaloes) in Temples especially during main festivals, the Vijayadashami (*dashain*). For people of Majhigaun, the grazing season inside KNP coincides with the *dasara mela* in the Khaptad. The herders who grazed livestock in the KNP actively participate in celebrating this event. The main attractions of this festival are cultural dance and songs (*deuda*, the most popular dance and songs of Far-Western Nepal).

4.4. Conclusions

There were variations in herd size and composition and grazing calendars and altitude across study sites. Herders kept different types of livestock in a herd to get multiple benefits at the same time. The transhumance was vertical whereby herders move their livestock in the high altitude rangelands in the summer season and come down to the settlements/villages in the winter season. The main reasons for movement of herds were in search of grazing resources, to avoid extreme temperature and to avoid overgrazing. The traditional *nawa pratha* exists in Khumjung which helps to fix movement dates whereas in two other sites the movement was related with the opening of NP, CA and CF for livestock grazing. Transhumance livestock production is one of the main income sources for herder's HHs economy and this system was integrated with agriculture in all sites. Traditional knowledge and locally evolved institutions and practices were important for the transhumance systems. The transhumance systems were evolved as a culture and represent the socio-cultural tradition of local people in the study areas.

Chapter 5 : Ecological role of transhumance grazing in the Himalayan rangelands

5.1. Introduction

In the previous chapter, I described the status of contemporary transhumance systems and their socio-economic and cultural significances. The purpose of this chapter is to show the ecological role of transhumance grazing in the Himalayan rangelands. This chapter helps to understand whether or not transhumance grazing is detrimental to plant biodiversity in Himalayan rangelands. For this, I focus on how transhumance grazing affects plant species richness and composition. First, whether or not the distance from *goth* represents grazing disturbance gradient is presented.This is followed by the pattern of species richness along the distances from *goths*. The results showing species richness pattern is supplemented by species composition. Finally, the relative importance of major environmental factors that describe species composition in each site is given.

5.2. Grazing gradient

The grazing gradient, in this study, refers to the changes in livestock grazing pressure with respect to distance from *goth*. Generally, there were decreasing trends for the mean level of dung and trampling with the increasing distance from *goths* (Figure 5.1). The results of the Kruskal-Wallis tests showed that the level of dung, level of trampling, and percentage bare soil significantly differed at different distances from *goths* ($P<0.05$ for all variables in all sites). Moreover, the plot scores from the Principal Component Analysis (PCA) (using level of dung, level of trampling and percentage bare soil) also decreased with the increase in distance from *goths*. However, the relationship was not linear (Figure 5.2). There was a gradual decline up to a certain distance followed by a slight increase (400 m at Sagarmatha National Park (SNP) and 200 m at Gaurishankar Conservation Area (GCA) and Khaptad National Park (KNP)) and again a gradual decline. The sinusoidal pattern is likely to be related to animal movement pattern from *goths* (see chapter 8). These results indicate that grazing pressure generally decreases with the increasing distance from *goths*, but not in a linear way.

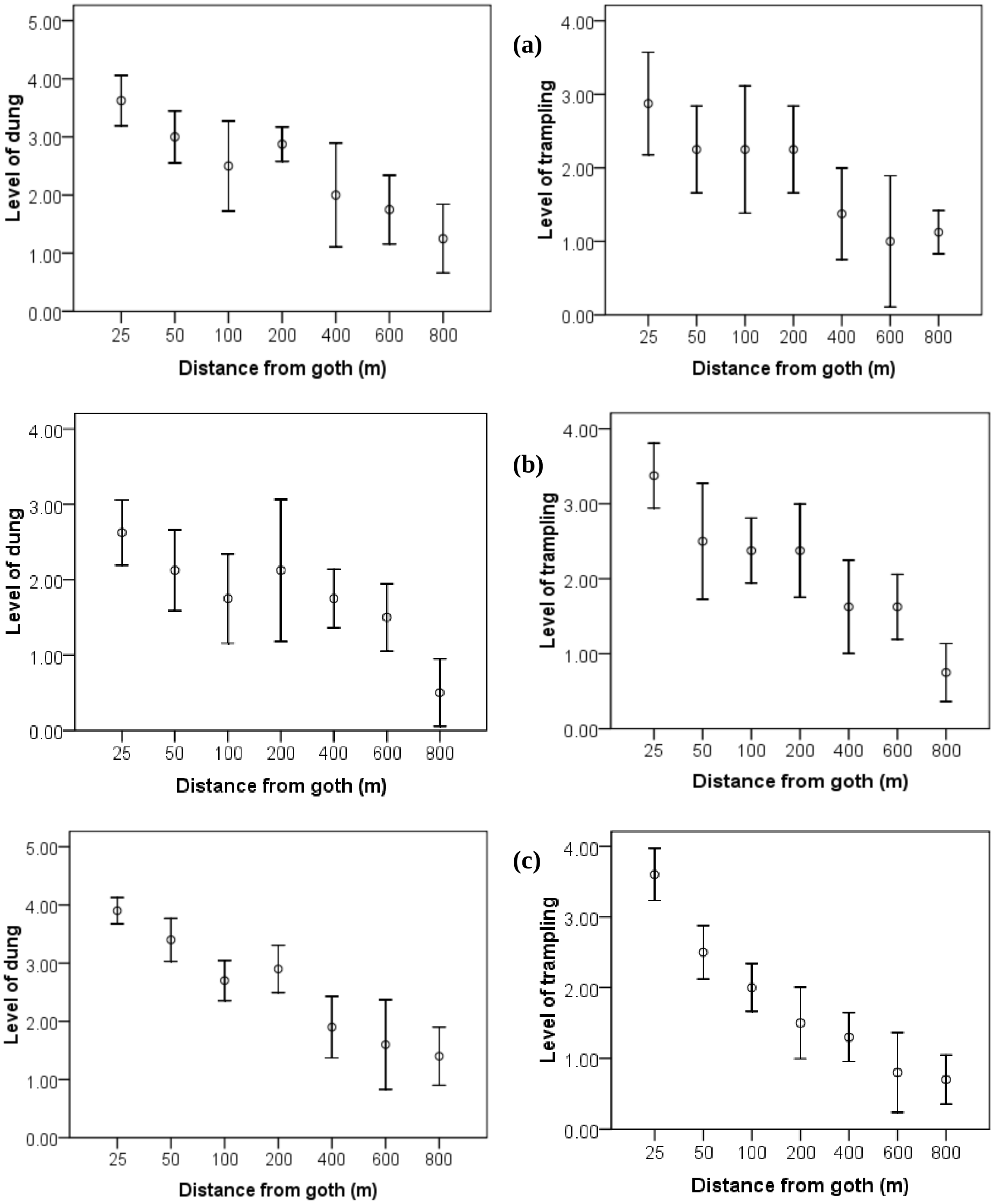

Figure 5-1: Level of dung and trampling at different distances from *goths*; a = SNP (Khumjung), b = GCA (Kalinchok) and c = KNP (Majhigaun)

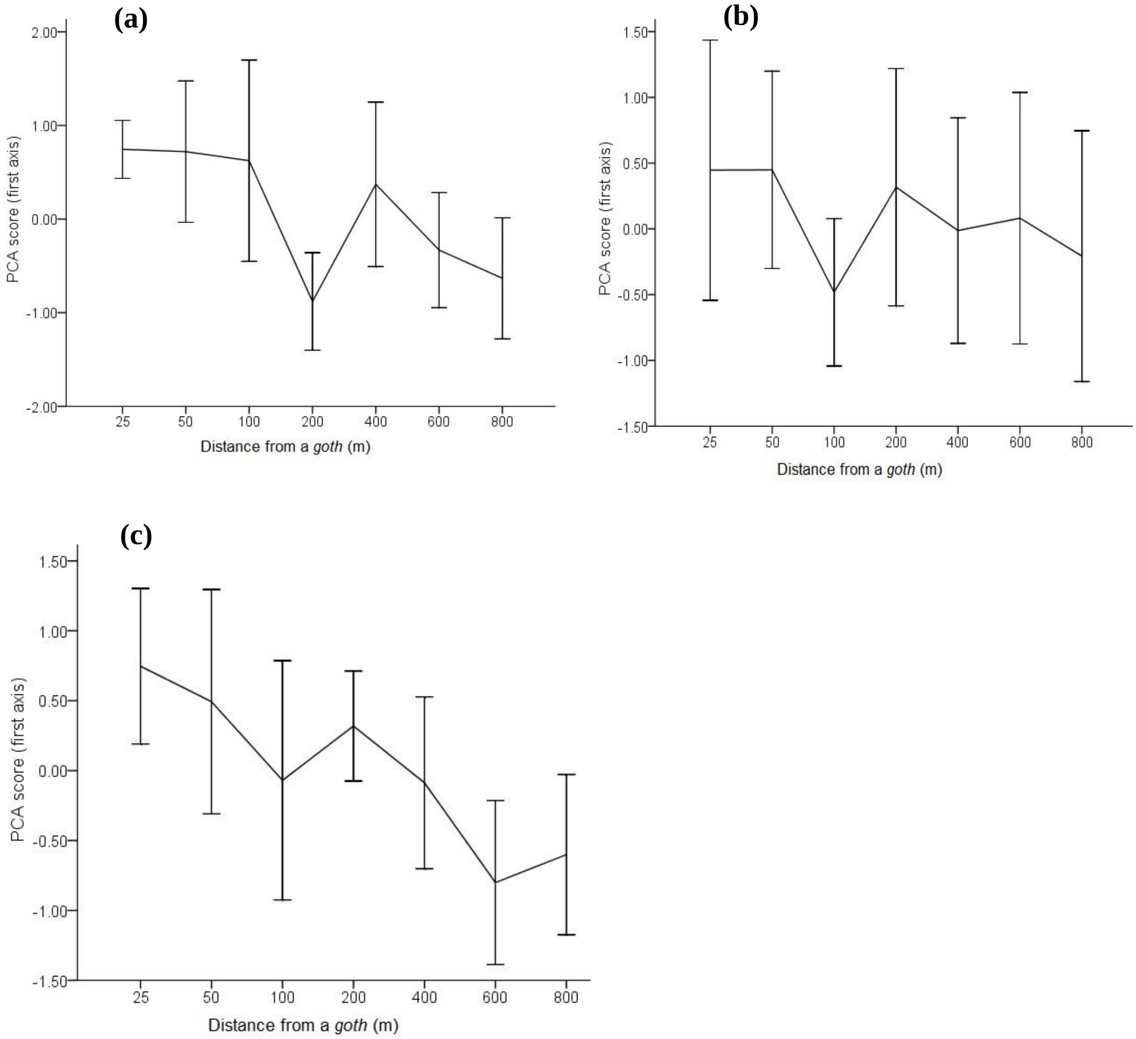

Figure 5-2: Line graph showing principal component analysis (PCA) score (mean±SE) of first axis using level of dung, level of trampling and percentage of bare soil. Error bars represents the 95% confidence interval. a = SNP (Khumjung), b = GCA (Kalinchok), c = KNP (Mahigaun)

5.3. Species richness across sites

A total of 99 plant species were found in the studied rangelands of Sagarmatha National Park (SNP) plots, 81 species in Gaurishaknar Conservation Area (GCA) and 102 for Khaptad National Park (KNP) (see Appendix E for full species information). The mean number of species per plot (α-diversity) was highest for GCA (18.98) and lowest for SNP (12.85). This was 15.8 for KNP (Table 5.1, Figure 5.3). It differed significantly across sites ($F_{2,161}$ = 247.2, P<0.05). It was highest for the GCA and the lowest for the SNP (Table 5.1). The turnover in species composition (β-diversity), as measured in terms of standard deviation units in Detrended Correspondence Analysis (DCA) (length of the gradient) was highest in SNP (Table 5.1).

Table 5-1: Total number of species encountered, mean species richness, and the length of the gradient in Sagarmatha National Park (SNP), Gaurishanbkar Conservaiton Area (GCA) and Khaptad National Park (KNP)

Site	Total number of species recorded	Mean species richness (α-diversity)	Length of the gradient (β-diversity)
SNP (Khumjung)	99	12.85	3.09
GCA (Kalinchok)	81	18.98	2.51
KNP (Majhigaun)	102	15.8	2.52

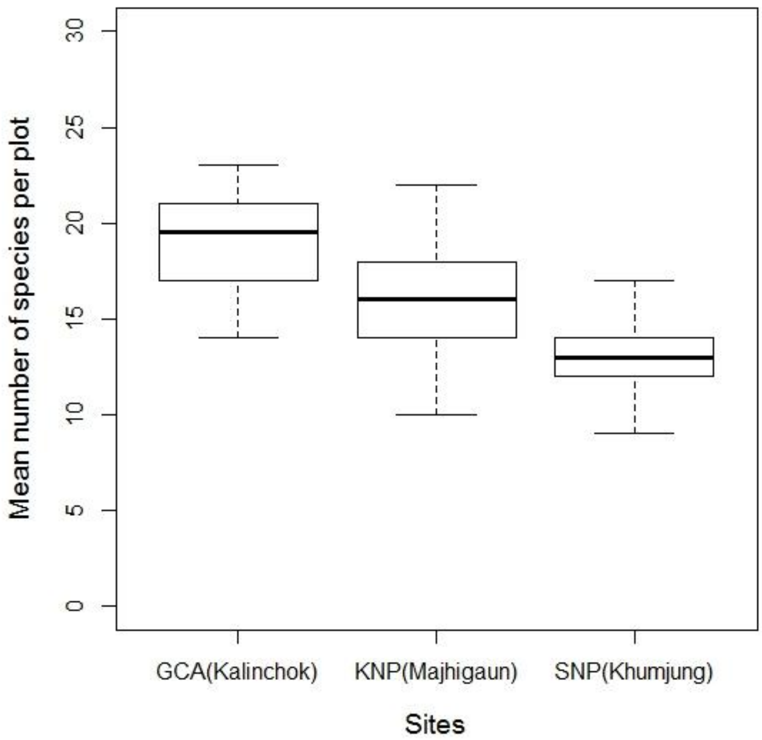

Figure 5-3: Mean number of species per plot (α-diversity) across sites

5.4. Pattern of species richness with distance from *goth*

The mean species richness also significantly differed at different distances from *goths* ($F_{6,161}$=34.9, P<0.05). The mean species richness per plot (α-diversity) at each distance category was highest at intermediate distances from the *goth* (Figure 5.4). However, the distance with the highest α-diversity varied across sites. In SNP, the α-diversity was highest at 200 m from the *goths*, whereas it was highest at 400 m in GCA and 600 m in KNP.

Similar to the α-diversity, the total number of species was highest at intermediate distance from *goth* in all sites (Table 5.2, Figure 5.5). The total number of species recorded were highest at 600 m distance from *goth* in SNP and KNP whereas it was highest and equal at both 400m and 600 m distane from *goth* in GCA (Figure 5.5).

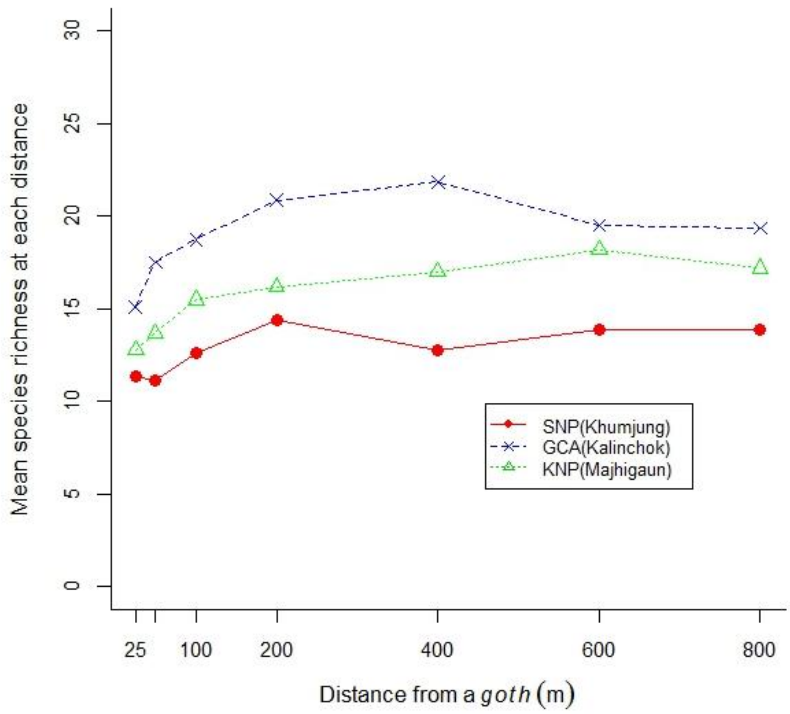

Figure 5-4: Mean number of species (α-diversity) per plot with distance from *goth*

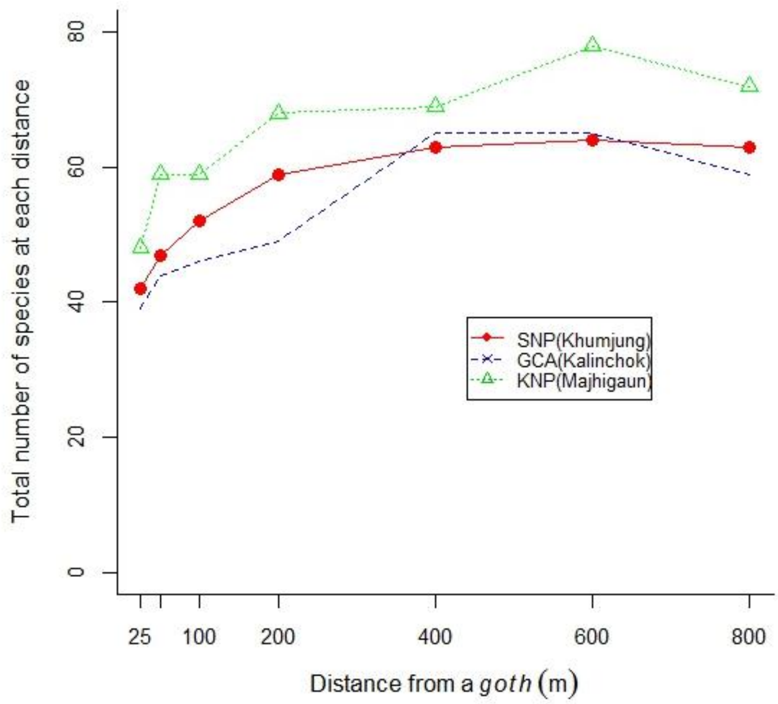

Figure 5-5: Total number of species at each distance from *goth*

Table 5-2: Mean number of species per plot and cumulative number of species at each distance category

Distance from *goth* (m)	Mean number of species per plot at each distance			Total number of species recorded at each distance		
	SNP (Khumjung)	GCA (Kalinchok)	KNP (Majhigaun)	SNP (Khumjung)	GCA (Kalinchok)	KNP (Majhigaun)
25	11.37	15.12	12.8	42	39	48
50	11.12	17.5	13.7	47	44	59
100	12.62	18.75	15.5	52	46	59
200	14.37	20.87	16.2	59	49	68
400	12.75	21.87	17	63	65	69
600	13.87	19.5	18.2	64	65	78
800	13.87	19.37	17.2	63	59	72

5.5.Species composition

5.5.1. Results of Canonical Correspondence Analysis and species composition

In all sites, first axis of Canonical Correspondence Analysis (CCA) most corresponded with altitude (Table 5.3). The second axis of CCA for SNP most corresponds with ground vegetation cover whereas it most corresponded with distance from *goth* in GCA and shrub cover in KNP. In SNP and KNP, distance from *goth* corresponds most with fourth axis. In GCA, there was a small difference in eigen values of first and second axis indicating that the distance from *goth* was equally influential in describing species compositon. However, the difference in eigen values of first and second axis were larger in SNP and KNP (Table 5.3).

Table 5-3: Results of Canonical Correspondence Analysis (CCA) for four axes obtained from the CCA including all significant environmental variables after forward selection

	Site											
	SNP (Khumjung)				GCA (Kalinchok)				KNP (Majhigaun)			
Ordination axis	Axis 1	Axis 2	Axis 3	Axis 4	Axis 1	Axis 2	Axis 3	Axis 4	Axis 1	Axis 2	Axis 3	Axis4
The highest interest correlation with	Alti	Grvc	Shrc	Dist	Alti	Dist	Mois	Slop	Alti	Shrc	Mois	Dist
Eigen values	0.48	0.29	0.23	0.11	0.18	0.12	0.08	0.07	0.29	0.12	0.11	0.08
Species environment correlations	0.96	0.85	0.83	0.74	0.91	0.93	0.75	0.80	0.94	0.82	0.72	0.71
Cumulative % variance of species	10.4	16.8	21.8	24.2	7.3	12.2	15.5	18.6	9.3	13.3	16.7	19.5
Cumulative % variance of species environment relation	38.3	62	80.4	89.3	33.0	55.0	69.7	83.7	39.8	56.6	71.4	83.4

Note: Abbreviations used in tables; Alti = Altitude, Grvc = Ground vegetation cover, Shrc = Shrub cover, Dist = Distance from *goth*, Mois = Moisture, Slop = Slope

The distribution of plant species and environmental variables towards the first two axis of CCA for each site are shown in CCA diagram (Figure 5.6, Figure 5.7 and Figure 5.8 for SNP, GCA and KNP respectively).

Interpretation of the CCA diagram: (i) site and species points display the variation in species composition over the sites, (ii) the arrow of an environmental variable points in the direction of maximum change of that environmental variable across the diagram, (iii) the length of the arrow is proportional to the rate of change in the direction, and (iv) environmental variables with long arrows are more strongly correlated with the ordination axis than those with short arrows and so closely related to the pattern of community variation in the ordination diagram (Ter Braak 1987; Ter Braak & Verdonschot 1995).

In SNP, axis-1 is correlated with altitude and axis-2 with ground vegetaion cover. The distance from *goth* was correlated with axis-4. Species such as *Gentiana depressa*, *Stipa* sp., *Fritillaria cirrhosa*, *Morina nepalensis* were found in the left hand side of the CCA diagram that represent the greatest change in altitude but the species such as *Potentilla fruticosa*, *Arisaema propinquum*, *Berberis mucrifolia* etc. were found in the plots with high shrub cover and located in right hand side of the CCA diagram. Furthermore, species such as *Cirsium falconeri*, *Ranunculus brotherusii*, *Geranium donianum* etc. were found in moist plots and are located at the top of the diagram. Species such as *Roscoea alpina*, *Aconitum spicatum*, *Carex* sp. etc. were found in the plots having high ground vegetation cover at distant plots from *goth* (Figure 5.6).

In GCA, the axis-1 is strongly positively correlated with altitude and axis-2 is correlated with distance from *goth.* Species such as *Juniperus indica*, *Juniperus squamata*, *Potentilla microphylla*, *Kobresia nepalensis* showed their affinity toward high altitude and plots with high shrub cover whereas species such as *Oxalis corniculata*, *Anaphalis busua*, *Fragaria nubicola*, *Gerbera nivea* were found at decreasing altitude and shrub cover in the plots. *Senecio chrysanthemoides, Pyracantha crenulata*, *Cirsium falconeri*, *Euphorbia wallichii* and *Plantago majors* were common at short distance from *goth* whereas species such as *Utrica hyperborea*, *Euphrasia himalayica*, *Allium wallichii*, *Rheum australe* etc. were found in plots further from *goth* (Figure 5.7).

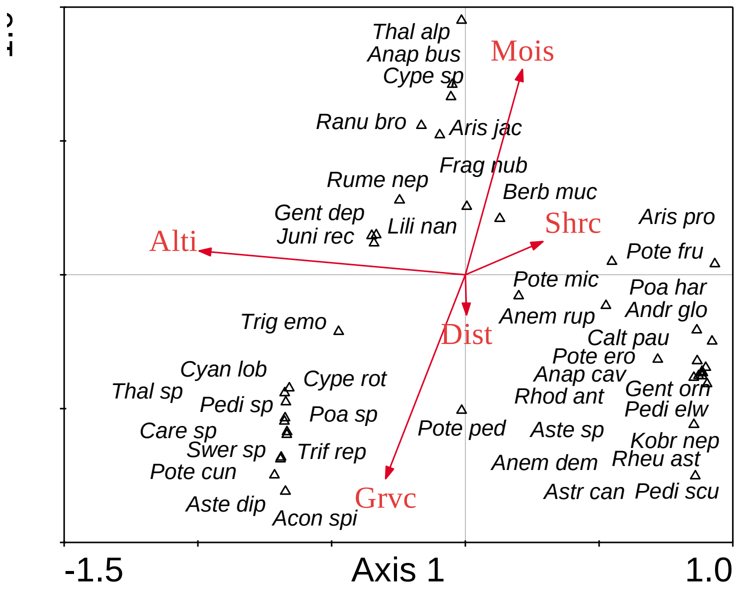

Figure 5-6: Canonical Correspondence Analysis (CCA) diagram (species and environment) for SNP (Khumjung)

Note: Only significant environmental variables in forward selection were presented in the graph. The environmental variables are abbreviated as: altitude = Alti, shrub cover = Shrc, distance from *goth* = Dist, ground vegetation cover = Grvc and moisture = Mois. The inclusion rule for species was fixed from 8 to 100% because graphs including all species were not readable. The abbreviations for plant species are derived as first four letter of species name and first three letter of generic name. For details of plant species abbreviations, please see Appendix E.

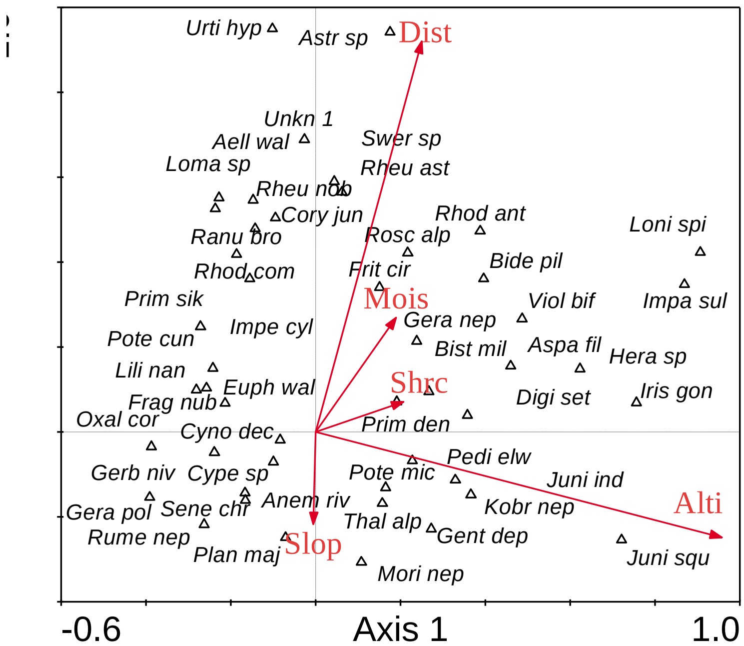

Figure 5-7: Canonical Correspondence Analysis (CCA) diagram (species and environment) for GCA (Kalinchok)

Note: Only significant environmental variables in forward selection were presented in the graph. The environmental variables are abbreviated as: altitude = Alti, shrub cover = Shrc, distance from *goth* = Dist, moisture = Mois and slope = Slop. The inclusion rule for species was fixed from 8 to 100% because graphs including all species were not readable. The abbreviations for plant species are derived as first four letter of species name and first three letter of generic name. For details of plant species abbreviations, please see Appendix E.

In KNP, axis-1 is strongly positively correlated with altitude whereas axis-2 is positively correlated with shrub cover. Similar to that of SNP, distance from *goth* was correlated with axis-4. Species such as *Ranunculus brotherusii*, *Potentilla cuneata*, *Geum elatum* etc. were found in plots at higher elevation whereas *Primula reptans*, *Gentiana depressa*, *Potentilla eriocarpa* were found at low altitude and located at left hand side of the CCA diagram. *Ageratum conyzoides*, *Rumex nepalensis*, *Plantago majors*, *Euphorbia wallichii* and *Cirsium falconeri* were more frequent near to the *goth*. Species such as *Oxalis corniculata*, *Juncus cuspidatus*, *Pedicularis hoffmeisteris* etc. were found in the plots a long way from *goth* (Figure 5.8).

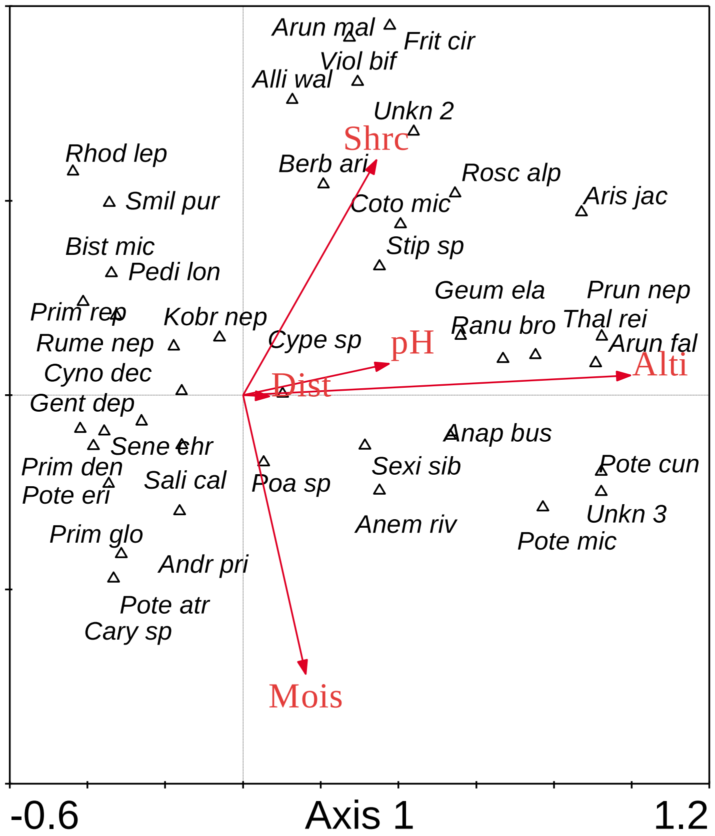

Figure 5-8: Canonical Correspondence Analysis (CCA) diagram (species and environment) for KNP (Majhigaun)

Note: Only significant environmental variables in forward selection were presented in the graph. The environmental variables are abbreviated as: altitude = Alti, shrub cover = Shrc, distance from *goth* = Dist, moisture = Mois and pH value = pH. The inclusion rule for species was fixed from 8 to 100% because graphs including all species were not readable. The abbreviations for plant species are derived as first four letter of species name and first three letter of generic name. For details of plant species abbreviations, please see Appendix E.

5.5.2. Factors affecting species composition

During forward selection in CCA, 5 environmental variables were significant in each site (Table 5.4). Altitude, moisture, shrub cover, and distance from *goth* were significant in all sites indicating their importance in determining species composition in all sites. Additionally, ground vegetation cover was significant in SNP, slope was significant in GCA and pH was significant in KNP. The altitude accounted for the highest percentage of floristic variance in all sites. The floristic variance explained by one factor also differed across sites. For example, distance from the *goth* accounted for the highest variance for GCA (4.53%) followed by for SNP (3.02%) and it was the lowest for KNP (2.38%).

Table 5-4: Variance explained by different environmental variables (only the significant are included using forward selection). The variance explained is the variance accounted when the variable is used as constraining variable in Canonical Correspondence Analysis (CCA) and is expressed as percentage of total inertia

Environmental variables	Sites								
	SNP (Khumjung)			GCA (Kalinchok)			KNP (Majhigaun)		
	Variance explained	F	P	Variance explained	F	P	Variance explained	F	P
Altitude	10.36	6.19	0.002	7.08	4.11	0.002	9.23	6.93	0.002
Shrub cover	2.15	1.48	0.016	2.59	1.40	0.050	3.4	2.7	0.002
Moisture	4.1	2.66	0.002	3.23	1.97	0.006	3.5	2.66	0.002
Distance form *goth*	3.02	2.01	0.002	4.53	2.68	0.002	2.38	1.37	0.002
Ground vegetation cover	5.93	3.44	0.002						
Slope				2.99	1.88	0.004			
pH							2.86	2.31	0.032

5.6. Conclusions

The results showed that the increase in distance from *goth* in the rangelands represents a grazing gradient. Grazing intensity was high in the plots near to *goth* and decreased with the increase in distance from *goth*. This is also reflected in species richness per plot (α-diversity) and species composition. It was found that the α-diversity, and total number of species were highest at intermediate distance and these values were small near *goths*. The grazing tolerant species were abundant in the plots very near to the *goth* whereas rare species were found in the plots at mid and further distance from *goths* with in 800m transects from *goths*. The grazing and other environmental factors such as altitude, shrub cover and moisture were significant in determining species composition in all sites.

Chapter 6 : Major drivers of, and responses to changes in the transhumance systems

6.1. Introduction

In previous chapters, I presented the socio-economic and cultural significances of transhumance systems (chapter 4) and then the ecological role in the rangelands (chapter 5) of the study areas. The purpose of this chapter is to describe possible major drivers of change to the transhumance systems and response to change in the study areas. First is a discussion of how globalisation has reached the study areas and how its impacts are relevant to the transhumance systems. The state of tourism and labour migration are presented along with their implications to the transhumance systems based on herders' perceptions. Second, relationships between conservation and transhumance systems are described. This section covers state policies and provisions for transhumance systems in different schemes of conservation, relevant to study areas. This is followed by an overview of local practices in those schemes of conservation and perceptions and attitudes of transhumant herders towards those schemes. Level of expectations of transhumant herders for transhumance and participation of transhumant herders in those conservation schemes are also given. Third, how climate change can be an additional pressure to the transhumance systems which are subjected to change pressure such as globalisation and conservation policies and practices is given. An overview of climate change in the study areas is given followed by the perception of herders towards change in different biophysical factors. The results of vulnerability analysis to climate change are given which also highlight the factors contributing to vulnerability. Fourth, major changes in the systems are presented, but there was a lack of previous data to identify change in many aspects of transhumance systems. Most of the results presented in this section are based on perceptions of herders in the study areas. However, previous data available from different sources are presented side by side. Finally, the local adaption strategies of transhumant herders in the study areas are given.

6.2. Globalisation

This section presents an overview of consequences of globalisation (tourism, labour migration) and their effect on transhumance systems in the study areas. First, the trend of tourism and labour migration are described. Second, the effects of tourism and labour migration are given.

6.2.1. Tourism

Out of three study sites, tourism was only relevant to Khumjung and it was virtually absent from the other two sites. There were only 19 and 1104 tourists visiting Khaptad National Park (KNP) and Gaurishankar Conservation Area (GCA) respectively in 2013 (*Nepal Tourism Statistics 2013*) and very few of them occasionally reach

Kalinchok and Majhigaun. Therefore, the analysis related to tourism is from Khumjung.

Both the Mt. Everest (top of the world) and Namche (gateway to the Mt. Everest) lie in the Khumjung. Furthermore, this area is one of the most popular trekking routes in Nepal and around the world. The tourism in the Sagarmatha National Park (SNP) started when Mt. Everest was first summited in 1953. In 1981, the area was included in the UNESCO World Heritage list. The number of tourists (foreigners) visiting the SNP is the same as the number of tourists visiting the Khumjung because the next available accommodation after the tourist information centre (at Chaurikharka) where records of visitors are maintained is Namche (lies in Khumjung).

Overall there is an increasing trend of tourism in SNP. The gradually increasing trend could not continue between 1999 and 2006 due to the political instability in the country. However, the decline in numbers of tourists visiting SNP during this period was less compared to a larger decline in other trekking routes of the country and number of foreigners visiting the country. The number of tourists has been steadily increasing after 2007 (Figure 6.1). The number of tourists visiting the park reached 36,750 in 2013 (*Nepal Tourism Statistics 2013*).

This may have had an impact on transhumance, notably on livestock numbers. There was a difference in the livestock holding between the households (HHs) involved in some kind of tourism and not involved in tourism (Figure 6.2). The mean livestock unit (LU) were significantly lower in the HHs receiving income from tourism than HHs who did not receive income from tourism ($t_{2,35}$ = 3.44, p = 0.004).

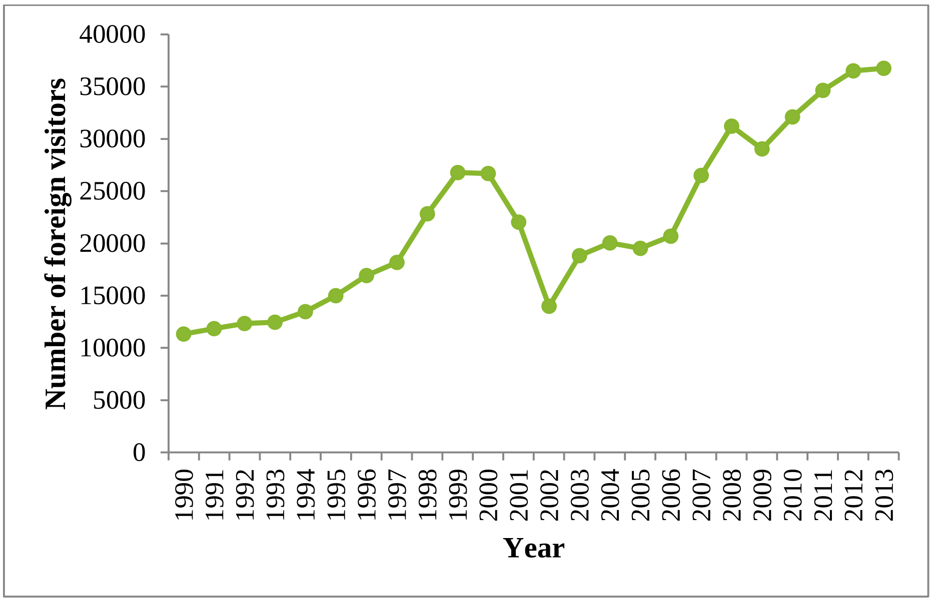

Figure 6-1: Trend of foreign visitors in SNP; **Source:** (*Nepal Tourism Statistics 2008*) and (*Nepal Tourism Statistics 2013*)

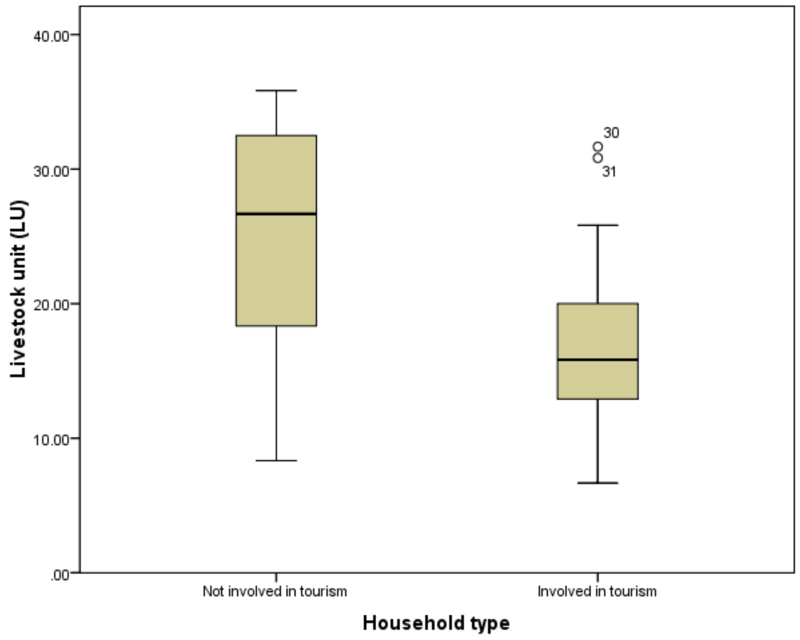

Figure 6-2: Mean livestock unit (LU) in the HHs not involved in tourism and involved in tourism; **Source:** Survey (2013)

The majority of herders agreed that tourism has reduced the number of HHs rearing livestock (Figure 6.3) and that tourism has increased the shortage of labour for livestock production, and they had reduced numbers of livestock due to tourism. The majority of them also agreed that tourism has increased their HHs income and they like to be involved in tourism (Figure 6.3). However, only less than one third of herders agreed that tourism has promoted local products and that they use livestock for tourism purposes. There were virtually no respondents who agreed that tourism has promoted local culture. The survey results were supported by findings from the focus group discussion (FGD). During FGD, herders mentioned that with the growth of tourism, many HHs started tourism business such as opening hotels and restaurants. Many local people started to be involved in mountaineering, guiding and portering. Herders mentioned that tourism has affected transhumance systems in three major ways. First, it created labour shortage for involvement in traditional systems. Second it raised HH incomes and reduced attachment to traditional systems. Third, it increased the flow of people, information and culture from other countries and increased involvement of local people in broader activities.

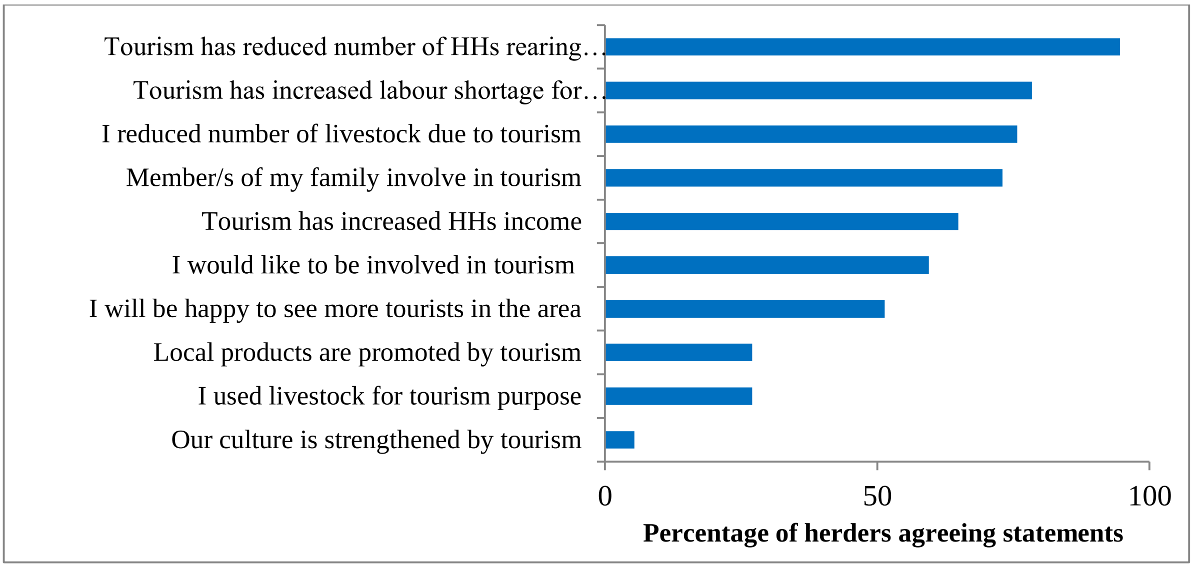

Figure 6-3: Percentage of herders agreeing (strongly agree + agree) statements; **Source:** Survey (2013)

6.2.2. Labour migration

The pattern of migration was different across study sites (Figure 6.4). In Khumjung, the migration from herder's family was very low. Only two out of 37 herders (5.4%) reported that their family member was outside the country. Therefore, further analysis was not made for Khumjung. In Kalinchok, about one third of herders (out of 54) mentioned that they have their family member working in a foreign country and one fourth having their family member working in a country other than India (i.e. Middle East, Gulf countries, Malaysia and South Korea). Only three herders mentioned that they had their family member working in India.

During FGD, herders mentioned that the migration pattern has changed in Kalinchok. In the past, some people of Kalinchok used to go to Kathmandu (the capital city of Nepal) and different cities of India. The migration to Kathmandu would be opportunistic and lasted for short durations. Now many youths have started to go to countries other than India. This has increased the income of the migrant's family and they gradually reduced traditional farming practices. Furthermore, this has also increased the migration of families towards Charikot (District headquarter) and Kathmandu.

In Kalinchok, there was a difference in the mean livestock unit (LU) between non-migrants and migrants (other than India) HH (Figure 6.5 a). The non-migrant HHs had significantly higher LU than in migrant's HHs ($t_{2,49} = 2.22$, $p = 0.031$).

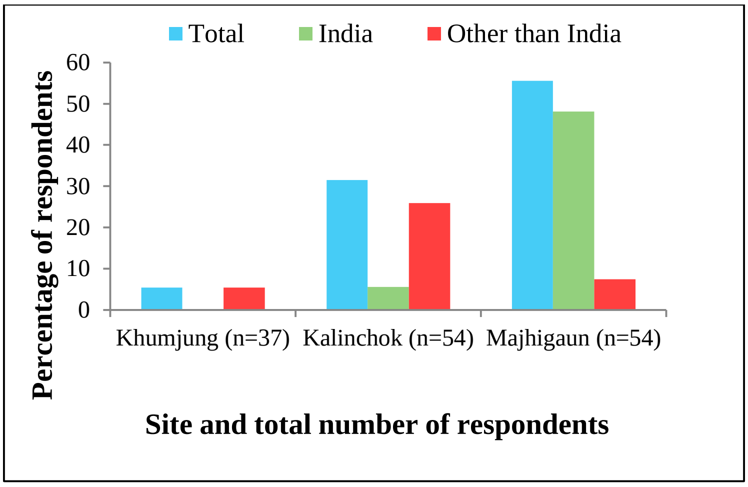

Figure 6-4: Percentage of HHs having member in foreign country; **Source:** Survey (2013)

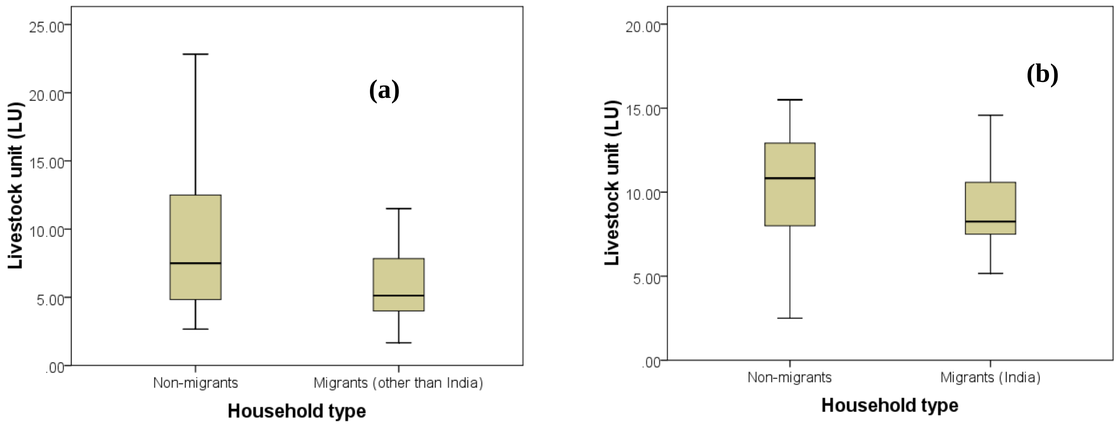

Figure 6-5: Mean livestock unit (LU) in migrants and non-migrants HHs; non-migrants and migrants (to countries other than India) HHs in Kalinchok (a) and non-migrants and migrants (to India) HHs in Majhigaun (b); **Source:** Survey (2013)

There were even more migrants in Majhigaun than in Kalinchok, however, the nature of migration was different. About 55% of herders (30 out of 54 surveyed) mentioned that they have their family member working in a foreign country and 48% (26) reported that their family members were in India or go to India each year. Only about 7.4% herders (4) reported that they have their family member working in a country other than India (Figure 6.4). Hence, transhumance might be partially important in seasonal opportunistic migration.

Herders in Majhigaun, during FGD, mentioned that seasonal migration to Indian cities was not new. It was the source of cash for many families even in the past which was used to buy clothes, salt and celebrate festivals. Generally, people go to India after planting crops and come back to harvest crops and celebrate festivals. Recently, youths have also started to go to other countries for work. But it is less common than in Kalinchok. People have to invest more money and they need passports, visas, and work permits to go to other countries which herders reported was difficult to manage.

However, they are not required to if going to India due to open borders of Nepal with India.

In Majhigaun, the mean livestock unit (LU) were slightly higher in non-migrants HHs than in the HHs whose family members were in India or seasonally migrate to India (Figure 6.5b). However, the difference was not significant ($t_{2,48}$ = 1.56, p = 0.124).

6.3. Conservation policies and practices

This section presents conceptual underpinning and an overview of conservation policies and practices of Nepal in different schemes of conservation which were relevant in the study areas (Table 6.1). This is followed by the perceptions and attitudes, expectation and participation of transhumant herders towards those schemes of conservation.

6.3.1. State policies related to Community Forest (CF), Conservation Area (CA) and National Park (NP) towards transhumance system

6.3.1.1. Community Forest (CF)

The history of Nepalese forestry can be classified into three phases; privatisation, nationalisation and participation. Forest management prior to 1957 is considered as privatisation based on a group's ownership where villagers managed their nearby forest based on indigenous practices to meet the locals' demands of fuel, fodder, timber, grazing etc. The forests were nationalised under the *Private Forest Nationalisation Act* (1957) for more than two decades. The period from 1978 to the present is considered as the community forestry phase which began with the shift in policy toward participatory forestry with the formulation of the National Forestry Plan in 1976. The National Forestry Plan (1976) was followed by the Panchayat Forest rules and Panchayat Protected Forest rules in 1978 with the provision for handing over limited areas of government forest to the local Panchayat. From 1978, there have been several legislative changes to facilitate the handing over process from government controlled to local people until the enactment of *Forest Act* (1993).

The *Forest Act* (1993) provides full authority to the users for the management of forest resources. This act defines community forest as the government forest handed over to the user groups for development, protection and utilisation. According to this act, the District Forest Officers hand over part of the national forest to a users' group (committee) called Community Forest Users Group (CFUG) as prescribed to develop, conserve, use and manage. The Forest Act (1993) also allows selling and distributing of forest products independently by fixing the price according to the approved operation plan (OP). The *Forest Act* (1993) and *Community Forestry Guidelines* (2008) do not limit forest boundaries to the politico-administrative boundaries and emphasise to demarcate CF boundaries based on traditional user rights. Furthermore, there is also a provision to classify users as primary, secondary and tertiary to allow for different user rights. These two provisions: CF boundaries based on traditional use and provision of different types of users within state policies seem able to accommodate transhumant herders, but power has been devolved to CFUGs to decide whether or not to allow grazing.

Table 6-1: Act and rules relevant to CF, CA and NP relevant to the study

Conservation measures	Studied sites	Relevant act and law
Community Forest (CF)	CFs around Kalinchok (GCA) and Majjigaun (KNP)	*Forest act* (1993), *Community Forestry Guidelines* (2008) *and Operation Plans of Community Forests*
Conservation Area (CA)	Kalinchok (GCA)	*National Parks and Wildlife Conservation Act* (1973) (the third amendment) and *Conservation Area Management Rules* (1996) and *Work Plan* of Conservation Area Management Committee (CAMC)
National Park (NP)	Khumjung (SNP)	*National Parks and Wildlife Conservation Act* (1973), *National Park and Wildlife Conservation Regulation* (1974), *Mountaion (Himalayan) Park Regulations* (1980), and Approved *Management Plan*
	Majhigaun (KNP)	*National Parks and Wildlife Conservation Act* (1973), *and Khaptad National Park Regulations* (1988)

The concepts of primary, secondary and tertiary users, were not found in the OPs of CFs reviewed from the study areas. In both OPs I reviewed near KNP (Khapurshwor in Majhigaun Village Development Committee (VDC) and Matuwa in Kalukheti VDC), it was mentioned that CFUG can decide whether or not to allow livestock grazing. Furthermore, the plans mentioned that an executive committee can decide punishment and fines if anyone violates decisions. Out of two operations plans I reviewed for CF near GCA, in one (Kalinchok in Kalinchok VDC), it was mentioned that grazing could be opened by the executive committee for some time in designated areas. The *chauri* herders who were traditionally using forests were allowed to graze, however, they had to pay fees per livestock. Grazing fees were different for herders who were member of CFUG to those who were not. Lopping trees and collecting firewood was completely banned which can create shortage of fodder. In another OP (Surre Nepame of Lapilan VDC) it was mentioned that grazing can be allowed only in designated areas and times for members of CFUG. If any herders who are not members want to graze *chauri*, they need to get approval from the executive committee for which the herder should pay fees per *chauri*. This suggests that the policies which were flexible for transhumant grazing were not reflected at local level policy documents, and priority was given to increase income of CFUGs.

6.3.1.2. Conservation Areas (CA)

The third amendment of the *National Parks and Wildlife Conservation Act* (1973) (NPWCA) allowed the Government of Nepal (GoN) to establish Conservation Areas (CAs) (section 3) and entrust the management of a CA to any institution (national or foreign) established with the objective of conserving nature and natural resources (section 16 b). This was considered as a paradigm shift in Nepalese nature conservation (Kollmair *et al.* 2003) because it allowed direct participation of local people in nature conservation and management. In 1996, GoN framed *Conservation Area Management Rules* (CAMR) which details the access, use and management of the CA using the power given by the act (section 33). Recent trends suggest that the GoN is more inclined to establish CA rather than NP (Nepal 2002).

Conservation Area Management Rules (1996) provides the right to divide CA into different Areas, form Area Conservation Offices, and appoint Conservation Officers for management (rule 5 and 6) of CA. The CAMR defined the general roles of the Main Office, Chief Officer and Conservation Officer. The rule also detailed how various types of user committees are formed and how profits generated are used for both conservation and social welfare projects. Conservation officers form a Conservation Area Management Committee (CAMC) with 15 executive members in each Village Development Committee (VDC) within CA and define the role and duties of such committee (rule 8 and 9). This committee prepares a work plan for five years and submits it to the Chief of CA through the Conservation Officer.

As CAMC are formed at VDC level, resources user from outside the VDC cannot be represented in the CAMC. This contradicts traditional use practices for some users such as transhumant herders who have utilised grazing areas across different VDC. CAMR also allows CAMC to prescribe and collect fees from herders to graze livestock and to use other natural resources (rule 25). Although five members are nominated by a Conservation Officer representing women, less advantaged castes, and social activists; it does not have any provision regarding the inclusion of seasonal herders in CAMC executive committee.

6.3.1.3. National Park (NP)

Formal conservation programmes in Nepal began with the passage of the *National Parks and Wildlife Conservation Act* (1973) (NPWCA). The act initially empowered GoN to create four types of protected areas (PAs); National Parks, Controlled (Strict) Nature Reserves, Wildlife Reserves and Hunting Reserves, and handed over rights to GoN to declare any areas as park or reserve. This act also empowered GoN to amend and frame regulations (section 33). This act was amended several times with the outcome of less control by government and increased involvement of local communities in the conservation. The 3rd amendment of this act allows the creation of a fifth type of PA namely Conservation Area (as discussed above in section 6.3.1.2) and 4th amendment (1993) provided Department of National Parks and Wildlife Conservation (DNPWC) with the power to establish a Buffer Zone (BZ).

The NPWCA removed many customary rights. This act prohibited pasturing domesticated livestock, occupying any kind of shelter or hut, clearing or cultivating land, felling or removing trees, shrubs or forest products. The NPWCA also allowed the military to patrol NPs and most of them are patrolled (Cameron 1995). Later the *Mountain National Park Regulation* (1979) allowed local people inhabiting mountainous parks to graze their livestock in the areas as permitted by the warden. This was more flexible for local users, however, management is still 'top-down', and grazing and collection of firewood was allowed only in designated areas and times. Provision of livestock grazing in the designated time and place defined by the warden might not fulfil the requirement of historically practised transhumance system. Furthermore, the regulations imposed by the NP made it impossible for herders to rely on natural resources to a customary degree.

SNP is governed according to the provisions of NPWCA, *National Park and Wildlife Conservation Regulation* (1974) and *Mountain National Park Regulation* (1979) (Table 6.1). The adjacent buffer zone is managed under the *Buffer Zone Management Rules* (1996). A management plan is prepared to guide the park activities. *The First Sagarmatha National Park Plan* (1981) continued to serve the park nearly for three decades. The Buffer Zone Management Plan was prepared in 2004 to manage community development, environmental conservation and sustainable use of local resources through the local participation. An Integrated Park and Buffer Zone Plan was prepared and implemented from July 1, 2006. This plan has emphasized cultural conservation as one of the management components and identified the needs for maintaining transhumance and agro-pastoral economy. However, there are no activities for immediate implementation, and grazing is often perceived as the main factor for degradation of habitats.

According to NPWCA, specific regulation can be formulated under the act to serve specific management needs of individual parks. Following this provision, a separate *Khaptad National Park Regulation* (1987) was framed by the GoN for KNP. This regulation also prohibits free livestock grazing in KNP (rule 7). However, this regulation had provision to allow livestock grazing inside KNP for specified time periods after paying grazing fees and obtaining written permission (licence) as issued by Chief Warden (rule 31).

6.3.2. Local practices in Community Forest (CF), Conservation Area (CA) and National Park (NP)

During FGDs, herders expressed feelings of exclusion from the initial process of forming OPs and CFUGs. They mentioned that there was not enough information, participation and discussion during the preparation of OPs and the formation of executive committees for CFs. Sometimes the meetings were held while most of the herders were in summer grazing areas. *Chauri* herders in Kalinchok mentioned that they didn't know when officials came, where they held meeting, who participated, and what they did. Later on, they were informed that they formed '*samudayik ban'* (community forest) and livestock grazing and lopping trees were banned. They mentioned that there was a shortage of grass/fodder in winter and raised questions how *chauri* survive in winter if lopping *kharsu* (oak trees) is banned. Herders mentioned that they were not consulted while setting CF rules. They suspected that local elites (locally called *tatha bata*) who had enough private land and sufficient fodder/grass might have influenced government officials and set rules. Herders from Kalinchok VDC mentioned that they were more affected by the CFUGs formed in the neighbouring VDCs because they did not allow them to graze livestock where they used to graze in winter season in the past.

While, I was in District Forest Office, Dolakha, a group of *chauri* herders were submitting (registering) application to District Forest Officer complaining about CFUGs. They mentioned that their traditional *chauri* rearing practice was about to vanish due to grazing restriction in CF. Herders also reported that they were physically assaulted and psychologically harassed by CFUGs. In the areas where they were traditionally grazing, the CFUGs restricted grazing and started to raise the amount of fees for per *chauri* for grazing. Therefore, they were requesting action against CFUGs and to create an environment so that they could continue their traditional practice.

In informal talks, executive members of CFUGs mentioned that grazing is the main reason for forest degradation. According to them, the collection of firewood, cutting trees to build new *goths* or repair old *goths* and lopping trees for fodder by herders had increased deforestation. They further stressed that it is everyone’s responsibility to manage forests. In response to my question whether they allow a herder who is not a member of CFUG to graze livestock in their CF, one executive member explained how the forest managed by them could be allowed to be used by others who are not a member and not involved in the management.

The CAMC was recently formed in Kalinchok. Pre-existing Kalinchok CF was converted to CAMC. Therefore, most of the herders mentioned that CAMC is the same as CF and they did not have different perceptions about CAMC. Herders indicate that there could be domination of local elites in CAMC as in CF. They suspected that local elites can influence the Conservation Officers during the preparation of Work Plan and can impose grazing restriction or increase grazing fees. Executive members of CAMC were positive about allowing grazing for the herders from the same VDC. They mentioned that the areas should be managed and used by all. However, they blamed *chauri* herders for forest destruction. They mentioned that CAMC cannot stop the raising of fees from *chauri* herders which was started while the area was under CF.

The herders from the SNP mentioned that the park has increased the livestock predation by snow-leopard and crop damage by wildlife such as wild boar. Herders also mentioned that park staff sometimes unnecessarily query them suspecting that they might have done illegal activities in the Park. Herders from KNP mentioned that they are suspected by the park staff for illegal activities such as hunting, poaching and cutting/lopping trees. Sometimes, Park does not allow bringing livestock inside the Park until late June. However, the opinion of Park staff was different. One officer related to NP mentioned that the current activities/practices implemented by NP in mountainous parks of Nepal in terms of access to resource use by local people are more flexible (supportive) than what is given in policies and rules. If rules are implemented as they are written, there is no space for invitation and consultation for local users to participate. He further argued that they consult, listen and understand problems of local people as much as possible.

6.3.3. Perception and attitude of transhumant herders toward Community Forest (CF), Conservation Area (CA) and National Park (NP)

The percentages of surveyed herders agreeing (strongly agree + agree) with each statement (item) under different variables and the results of χ^2 test showing whether the proportions of herders agreeing differ for different schemes of forest management/conservation, are given in table 6.2.

Table 6-2: Percentages of herders agreeing by statements related to positive perception and attitude (PPA) and negative perception and attitude (NPA)

Variable	**No.**	**Statement**	**% of respondents agreeing with the statement**			**χ^2-value**	**DF**	**P-value**
			CF (n=108)	CA (n=54)	NP (n=91)			
PPA	1	CF/CA/NP protect natural environment	25.0	27.8	29.7	0.55	2	.759
	2	CF/CA/NP has benefited local people	4.6	0.0	3.3	2.53	2	.282
	3	CF/CA/NP has increased income of local people	36.1	0.0	12.1	34.88	2	.000
	4	CF/CA/NP has benefited livestock herders	36.1	20.4	25.3	5.23	2	.073
	5	CF/CA/NP has not affected livestock herders	23.1	1.9	47.3	36.83	2	.000
NPA	1	CF/CA/NP has affected livestock rearing pattern	29.6	0.0	59.3	54.78	2	.000
	2	CF/CA/NP has reduced livestock number	40.7	51.9	73.6	21.84	2	.000
	3	CF/CA/NP has decreased livestock herders	42.6	42.6	80.2	33.50	2	.000
	4	CF/CA/NP has increased livestock loss (predation)	7.4	75.9	67.0	100.86	2	.000
	5	CF/CA/NP has increased crop damage due to wildlife	8.3	68.5	81.3	117.75	2	.000

Source: Survey (2013)

For all statements under positive perception and attitude (PPA), percentage of herders agreeing was less than 50% for all schemes. Percentages of herders agreeing with three statements under PPA (1, 2 and 4) were not significantly different; however percentage of respondents agreeing with remaining two statements under PPA (3 and 5) differed in CF, CA and NP (Table 6.2).

For all statements under negative perception and attitude (NPA) in CF and two statements in CA (1 and 3), the percentage of herders agreeing were less than 50%. However, for remaining three statements (2, 4 and 5) under NPA in CA and all statements in NP, there were more than 50% of herders who agreed with these statements. Furthermore, the percentage of herders agreeing with each statement under NPA significantly differed for different schemes (Table 6.2).

The percentage of responses in each response category after integrating responses for all statements under PPA is also reported (Figure 6.6a). There were less than 30% responses agreeing with statements under PPA in all schemes. While integrating responses for all statements under NPA, there were only about 25% responses agreeing on CF whereas the figure was about 50% in CA and more than 70% for NP (Figure 6.6 b). These suggest that negative perception and attitudes were high in NP and CA than in CF.

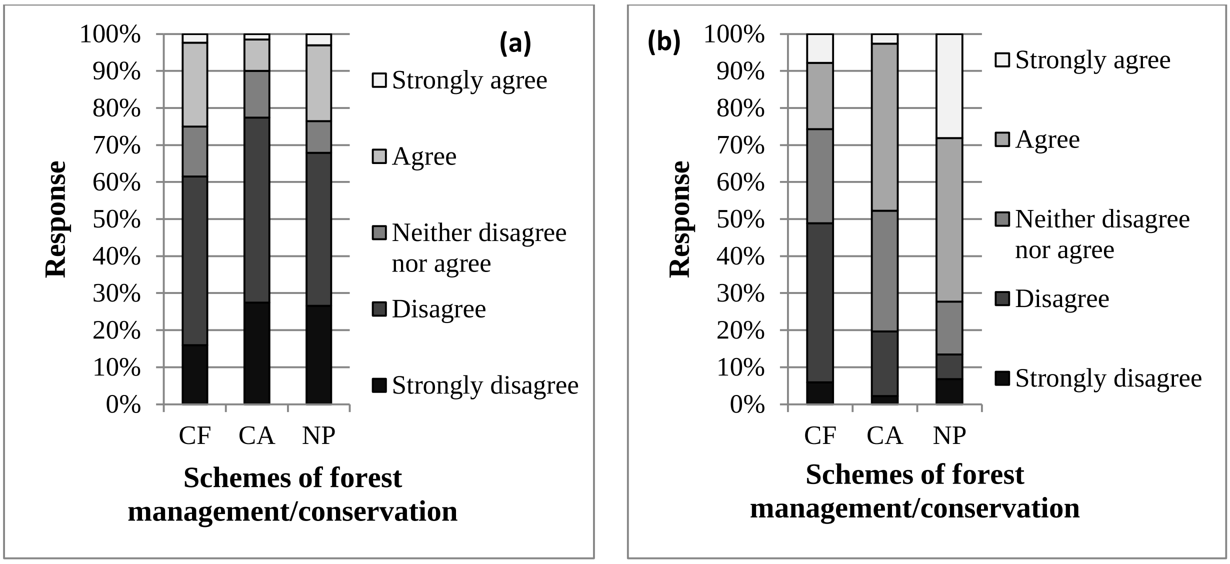

Figure 6-6: Positive perceptions and attitudes (a), Negative perceptions and attitudes (b) towards CF (n = 540), CA (n = 270) and NP (n = 455); **Source:** Survey (2013)

6.3.4. Expectation and participation of transhumant herders towards CF, CA and NP

The majority of surveyed herders agreed with many statements under expectations (EXP) in all schemes of management/conservation (Table 6.3). There were more than 50% of respondents agreeing with the first four statements in all schemes. For one statement (5), less than 50% agreed in CF and CA but almost all agreed for NP. For the last two statements (6 and 7), there were less than 50 % herders agreed in CF and NP but more than 90% agreed in CA (Table 6.3). The proportion of respondents agreeing did not significantly differ for three statements (2, 3 and 4) under expectations for different schemes of forest management/conservation, but for the remaining 4 statements (1, 5, 6 and 7) it differed significantly. While integrating responses for all statements under EXP, there were more than 65% of the responses who agreed (strongly agree + agree) with these statements (Figure 6.7a).

Table 6-3: Percentages of herders agreeing by statements related to expectation (EXP) and participation (PAR)

Variable	No.	Statement	% of respondents agreeing with the statement			χ^2-value	DF	P-value
			CF (n=108)	CA (n=54)	NP (n=91)			
EXP	1	CF/CA/NP should allow free grazing	98.1	56.0	81.3	76.10	2	.000
	2	CF/CA/NP should allow collection of grass	97.2	92.6	97.8	3.02	2	.221
	3	CF/CA/NP should provide route for livestock movement	71.3	72.2	70.3	0.06	2	.970
	4	CF/CA/NP should allow seasonal grazing for traditional herders	79.6	77.8	79.8	3.81	2	.321
	5	CF/CA/NP should allow collection of firewood	36.1	46.3	97.8	84.41	2	.000
	6	CF/CA/NP should allow collection of wild fruits and vegetables	41.7	92.6	46.2	41.26	2	.000
	7	CF/CA/NP should allow collection of medicinal plants	46.3	90.7	44.0	35.65	2	.000
PAR	1	I am satisfied with the current management of CF/CA/NP	36.1	13.0	15.4	16.12	2	.000
	2	I help CF/CA/NP	24.1	53.7	34.1	14.09	2	.001
	3	I would like to be involved in development and management of CF/CA/NP	19.4	83.3	17.1	76.28	2	.000

Source: Survey (2013)

There were less than 50% of surveyed herders agreeing with each statement under participations (PAR) in CF and NP. However, there were more than 50% herders in two statements (2 and 3) and less than 50% in one statement (1) for CA. Proportion of respondents agreeing with each of three statements under participation differed significantly (Table 6.3). There were only about 25% of responses agreeing to participation in CF whereas it was about 50% in CA and about 40% in NP (Figure 6.7 b).

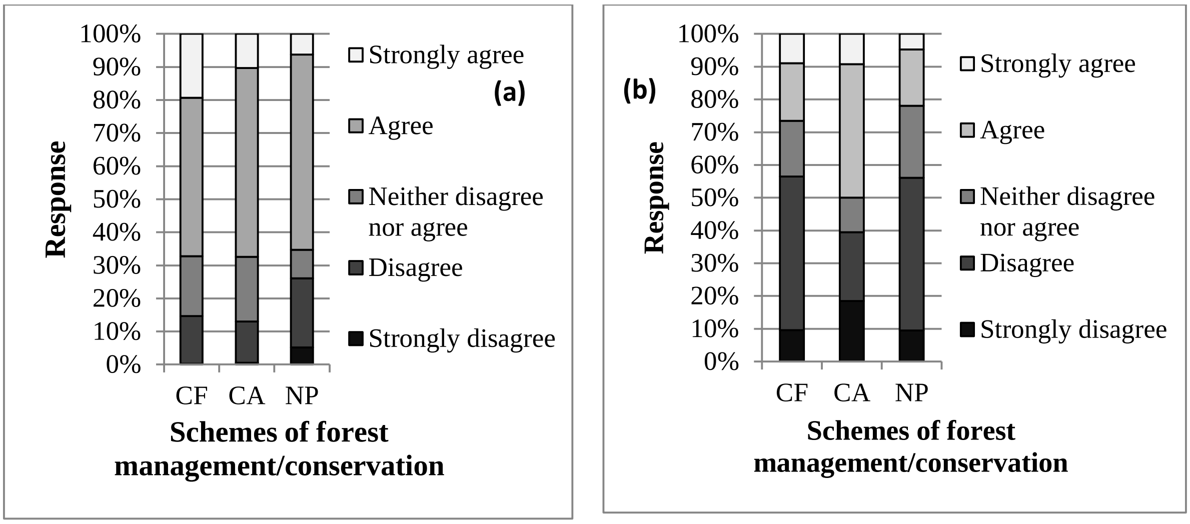

Figure 6-7: Expectations (a) of transhumant herders towards CF (n = 756), CA (n = 378) and NP (n = 637) and participations (b) of transhumant herders toward CF (n = 324, CA (n = 162) and NP (n = 273); **Source:** Survey (2013**)**

6.4. Climate change

This section covers an overview of climate change in the study areas (which is presented based on trends of key climatic variables), perceptions of transhumant herders towards change in biophysical indicators and vulnerability of herders to the climate change.

6.4.1 Trends of temperature and rainfall

Climate change can affect traditional social-ecological systems (TSESs) in different ways. Temperatures (annual, summer and winter) showed increasing trend for all study sites. The rate of increase was higher for winter season than those for annual and summer season (Table 6.4, Figure 6.8). The analysis of rainfall did not show a uniform pattern as did temperature. Rainfalls showed decreasing trend for Khumjung and Kalinchok whereas it was increasing for Majhigaun (Table 6.4, Figure 6.9).

Table 6-4: Temperature trends (1977-2007) in the study areas

Study area		**Khumjung/SNP**	**Kalinchok/GCA**	**Majhigaun/KNP**
Temperature trend (˚C /yr)	Annual	0.025	0.036	0.029
	Summer	0.003	0.025	0.018
	Winter	0.045	0.048	0.048
Rainfall (mm) and rainfall trend (mm/yr)	Annual	1873.55	1522.58	1453.45
	Annual trend	-3.91	-3.53	1.37
	Monsoon	1483.17	1181.13	1124.47
	Monsoon trend	-3.92	-3.36	1.89
	Winter	47.47	53.44	118.15
	Winter trend	-0.13	-0.11	0.03

Source: APHRODITE (2014)

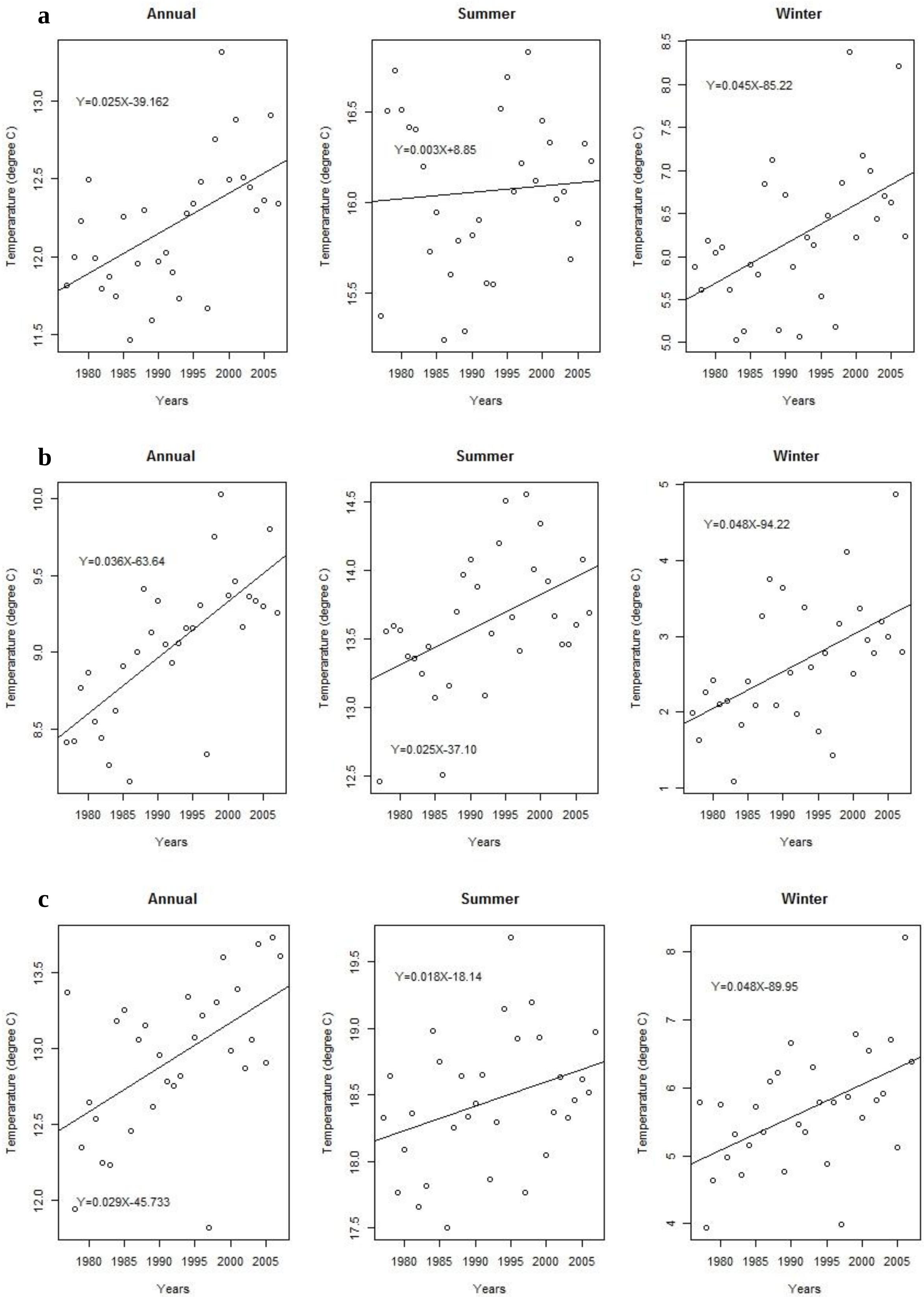

Figure 6-8: Temperature trends (1977-2007) for the study areas; Khumjung/SNP (a), Kalinchok/GCA (b) and Majhigaun/KNP (c); S**ource:** APHRODITE (2014)

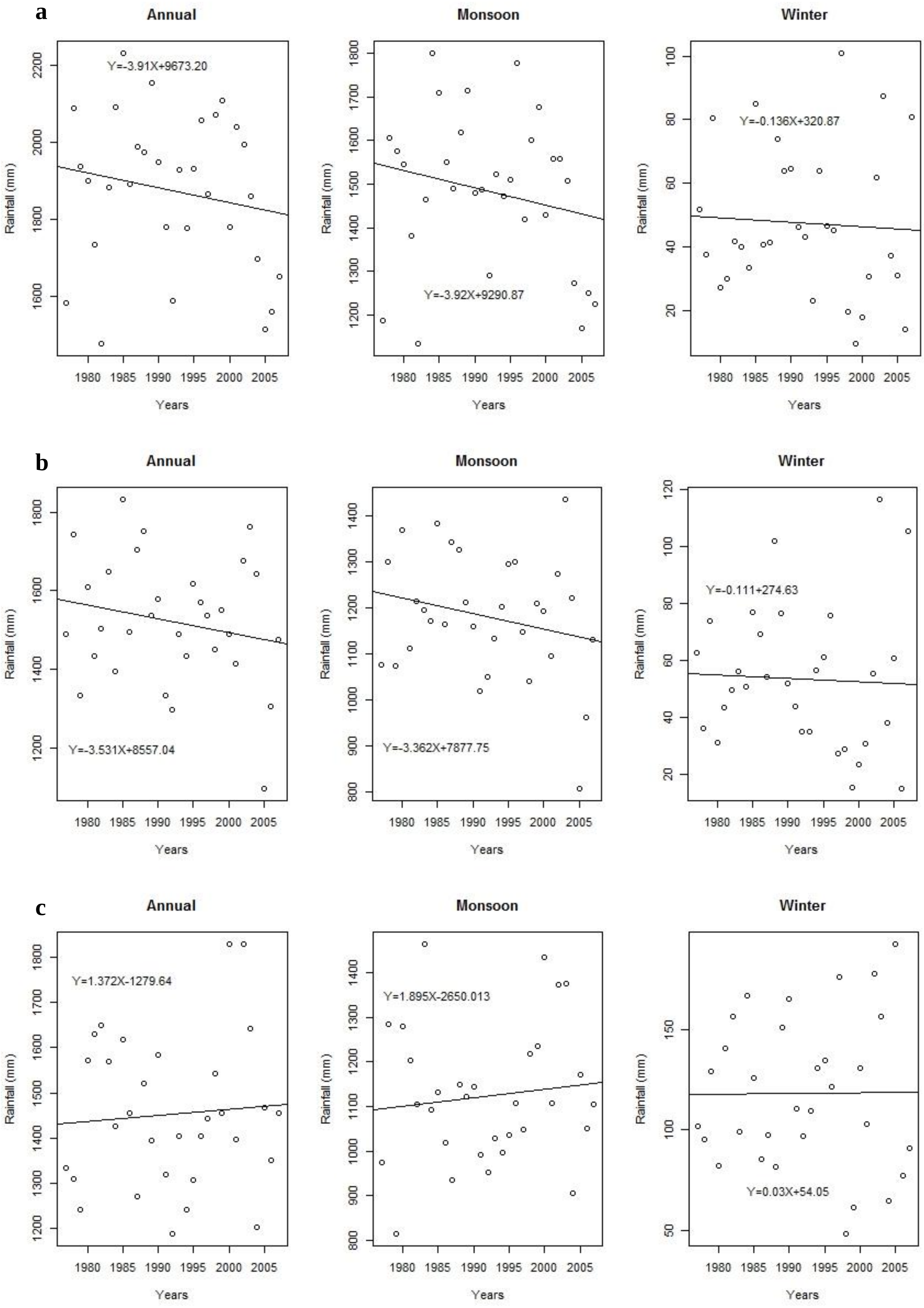

Figure 6-9: Rainfall trends (1977-2007) of study areas; Khumjung/SNP (a), Kalinchok/GCA b) and Majhigaun/KNP (c); S**ource:** APHRODITE (2014)

6.4.2 Perceived changes in biophysical indicators

Herders' levels of agreement towards changes in other bio-physical indicators related to water resources, rangelands and livestock were collected. Some statements were directly related to livestock; for instance, the statement "new livestock diseases have appeared" whereas others were more indirect, for example, the statement "early induction of greenery in the rangelands". However, all the statements have direct or indirect implications to the transhumance system.

For some statements, the majority of herders agreed in all sites and the proportion of the herders agreeing these statements were not different by site. These statements include; fast melting of snow in the rangelands, early onset of summer season, early growth in greenery in the rangelands, early flowering/maturing of plants in the rangelands, and appearance of new plant species in rangelands (Table 6.5).

Table 6-5: Level of agreements to the changes in bio-phisical indicators across sites

SN	Statements	Percentage of respondents agreeing with the statements (Strongly agree+ Agree)				Test statistics		
		Khumjung/SNP	Kalinchok/GCA	Majhigaun/KNP	Total	χ^2-value	DF	P-value
1	Melting of snow in the grassland is faster	100.0	98.1	98.1	98.6	0.695	2	0.707
2	Water sources are drying up	89.2	100.0	38.9	74.5	58.7	2	0.000
3	There is increase in drought	94.6	92.6	68.5	84.1	15.79	2	0.000
4	Early onset of summer	81.1	72.2	74.1	75.2	0.979	2	0.613
5	Early growth of greenery in the rangelands	83.8	87.0	79.6	83.4	1.07	2	0.584
6	Early flowering/maturing of plants in the rangelands	78.4	66.7	57.4	66.2	4.32	2	0.115
7	New species of plants are appearing in rangelands	67.6	74.1	74.1	72.4	0.584	2	0.747
8	New livestock diseases have appeared	51.4	94.4	81.5	78.6	24.67	2	0.000

Source: Survey (2013)

For some statements, most of the herders agreed (strongly agree + agree), however, proportions of respondents agreeing significantly differed across sites. These statements on impacts included; the drying up of water resources, increase in drought and the appearance of new livestock diseases. A larger proportion of herders from Khumjung and Kalinchok agreed (agree + strongly agree) with statements such as water resources were drying up and there was increase in drought than did respondents from Majhigaun. However, a larger proportion of herders in Kalinchok and Majhigaun

agreed with the statement that new livestock diseases appeared than those who agreed with thisin Khumjung (Table 6.5).
Impacts of climate change were also discussed during FGD and participatory observation of rangelands. Herders indicated that the increased temperature due to climate change had increased pests and diseases. The increase in incidence of tick and diarrhoea were perceived by the herders in Majhigaun. They also mentioned that abortions were more frequent these days as compared to the past. The black flies are more prevalent in the forest and scrub vegetation in the sub-alpine region of Kalinchok. In Majhigaun, herders reported that high altitude livestock such as yak lost immunity to lowland cattle diseases and suffered frequently from water and vector borne diseases.

Perceived water shortage has emerged as a problem in the winter settlements of Kalinchok and Khumjung. Some herders started to keep their livestock only for short durations because of the shortage of water where water sources have repeatedly dried up. Some springs in Kalinchok had already dried and become extinct whereas water volume and duration of water availability has decreased in others. Snow is a major source of moisture in high elevation rangelands. Snow would melt slowly and provide water for a long time in the past. However, the declining amount of snowfall and its fast melting has increased drought and decreased grass availability and productivity of the rangelands. They have also perceived that grasses in the rangelands started to mature and flower earlier and their palatability was reduced.

In addition, herders explained that there is an invasion of certain species in the rangelands. In Khumjung, they reported that *Iris goniocarpa*, *Euphorbia stracheyi* and *Caragana species* were increasing. In Kalinchok, the coverage of Chutro (*Berberis aristata*) and Ghangaru (*Pyracantha crenulata*) increased in high altitudes and Banmara (*Eupatorium adenophorum)* increased in low altitudes. Furthermore, the flowering and fruiting season of Laliguras (*Rhododendron arboreum*), Aisalu (*Rubus calycinus*) and Kaphal (*Myrica esculanta*) has shifted to earlier in the season. They linked it to the unpredictable rainfall and rise in temperature. These observations suggest that transhumant herders in the Himalayas have noticed changes in bio-physical indicators due to climate change. These changes might have direct or indirect implications to the transhumance systems.

6.4.3 Vulnerability of transhumant herders to climate change

The indicator based vulnerability analysis helps to compare vulnerability and factors contributing to the vulnerability. Higher vulnerability may indicate difficulty in adapting. The results of the vulnerability analysis are presented in two different ways. First, the results obtained from the assessment of individual major components and sub-component's contributions to each of the major components are presented together with the overall livelihood vulnerability index (section 6.4.3.1). Second, the estimated values for the different dimensions (sensitivity, exposure and adaptive capacity) of climate vulnerability index are presented (section 6.4.3.2).

6.4.3.1. Livelihood vulnerability of transhumant herders

The overall livelihood vulnerability index (LVI) did not greatly differ across study sites. It was slightly higher for Majhigaun (0.417) as compared to Khumjung (0.406) and Kalinchok (0.382). These indexed values are relative rather than absolute and showed that transhumant herders of Majhigaun had the highest vulnerability. Indexed values for the components and sub-components (indicators) demonstrate more dramatically the factors that are contributing more or less to the vulnerability of a particular site.

The indexed values for 'socio-demographic profile' components did not largely vary across sites (Table 6.6, Figure 6.10). However, if one examines the sub-components, there is variation. For example, the dependency ratio (dependent/independent people) in Khumjung was very low as compared to Kalinchok and Majhigaun. There were more women head of households (HHs) in Kalinchok than in the other two sites. The percentage of HHs where HHs heads had not attended school were similar across sites. The indexed value for 'livelihood strategies' was highest in Kalinchok than in Khumjung and Majhigaun. This was largely a function of the highest indexed value for the 'livelihood diversification index' attributed to the low diversification of HH's income sources. Furthermore, there were large numbers of HHs solely depending on agriculture and livestock for their income and livelihood, which is associated with vulnerability.

The 'health' component increased the vulnerability of transhumant herders in Majhigaun as compared to Khumjung and Kalinchok (Table 6.6, Figure 6.10). This is because transhumant herders of Majhigaun had to travel a long distance to reach hospitals. In addition, there were large numbers of people visiting *dhami-jhakri* (traditional witch doctor) when herders, family members or livestock become sick. This may further worsen the situation of patients. However, the herders of the other two sites believe less in *dhami-jhakri* and they had relatively easy access to health centres. The indexed value for 'social networks' was fairly similar across sites. It was slightly lower in Majhigaun than in Khumjung and Kalinchok. The indexed values for this component showed that transhumant herders exchange help with each other when required and they have solidarity to fight in emergency situations.

The 'food' component had the highest score for Khumjung (Table 6.6, Figure 6.10). This is because very few crops are grown due to the cold climate in high altitude and the food produced locally is sufficient to feed for a few months only. The indexed value for 'water' was higher for Majhigaun than for Khumjung and Kalinchok because the majority of villagers in Majhigaun use natural sources of water (river, pond and springs) and water availability was also not consistent. However, in Khumjung and

Kalinchok there were community level drinking water taps with more consistent water supplies which reduced the indexed values for 'water' in these sites.

The indexed value for 'natural disasters' was highest for Khumjung because herders of Khumjung experience more frequent natural disasters such as landslides and avalanches with death and casualties of human and livestock. In the other two sites, such events were less frequent. The 'climate variability index' which was calculated based on percentage of herders who perceived changes in key climatic variables was almost the same for all study sites (Table 6.6, Figure 6.10). This is because herders have perceived changes in climatic variables regardless of sites.

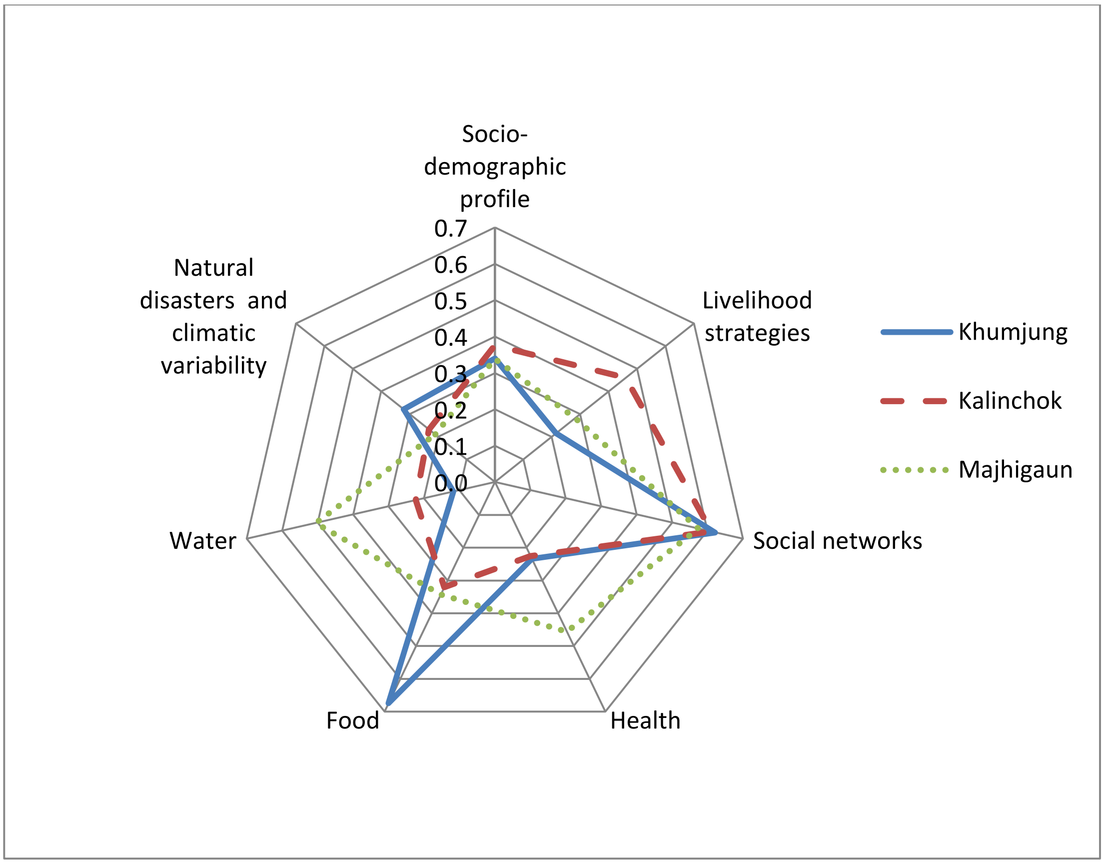

Table 6-6: Indexed values for climatic vulnerability for components and sub-components

Components	Indexed value for each component			Indicators or sub-components	Indexed value for each sub-components		
	Khumjung/ SNP	Kalinchok/ GCA	Majhigaun/ KNP		Khumjung/ SNP	Kalinchok/ GCA	Majhigaun/ KNP
Socio-demographic profile	0.340	0.376	0.339	Dependency ratio	0.049	0.108	0.128
				Percent of female headed HHs	0.324	0.407	0.259
				Percent of HHs where head of the HHs has not attended school	0.647	0.611	0.630
Livelihood strategies	0.216	0.460	0.282	Average livelihood diversification index	0.377	0.547	0.310
				Percent of HHs with family member working in a different community	0.135	0.574	0.590
				Percent of HHs solely dependent on agriculture and livestock as a source of income	0.135	0.259	0.018
Health	0.234	0.226	0.456	Average time to health facility (at least with MBBS doctor)	0.215	0.103	0.776
				Percent of HHs with family members with chronic ill	0.297	0.148	0.148
				Percent of HHs going to witch doctors during illness	0.189	0.426	0.444
Social networks	0.622	0.611	0.574	Average Receive: Give ratio			
				Percent of HHs received assistance from social networks	1.000	0.667	0.556
				Percent of HHs provided assistance to others	1.000	0.981	1.000
				Percent of HHs borrowing money from others	0.243	0.407	0.667
				Percent of HHs lending money to others	0.243	0.389	0.074
Food	0.674	0.320	0.343	Average number of months HHs struggle to find food	0.648	0.508	0.452

Components	Indexed value for each component			Indicators or sub-components	Indexed value for each sub-components		
	Khumjung/ SNP	**Kalinchok/ GCA**	**Majhigaun/ KNP**		**Khumjung/ SNP**	**Kalinchok/ GCA**	**Majhigaun/ KNP**
				Average crop diversity index	0.700	0.133	0.233
Water	0.117	0.223	0.506	Percent of HHs reporting water conflicts	0.351	0.537	0.407
				Percent of HHs that utilize natural water source	0.000	0.078	0.774
				Percent of HHs that do not have consistent water supply	0.000	0.056	0.337
Natural disasters	0.6092	0.441525	0.4001	Average number of flood, drought, and cyclone events in the past 5 years	0.518	0.118	0.118
				Percent of HHs that do not receive a warning before natural disasters	1.000	1.000	1.000
				Percent of HHs with an injury or death as a result of natural disasters in the last 5 years	0.351	0.111	0.075
				Percent of HHs with an injury or death to their livestock as a result of natural disasters in the last 5 years	0.568	0.537	0.407
Climatic variability	0.033	0.023	0.033	Summer temperature perception index	0.029	0.027	0.022
				Winter temperature perception index	0.037	0.022	0.021
				Total rainfall perception index	0.034	0.024	0.022
				Summer months rainfall perception index	0.04	0.025	0.02
				Winter months rainfall perception index	0.029	0.019	0.019

Components	Indexed value for each component			Indicators or sub-components	Indexed value for each sub-components		
	Khumjung/ SNP	Kalinchok/ GCA	Majhigaun/ KNP		Khumjung/ SNP	Kalinchok/ GCA	Majhigaun/ KNP
				Snowfall perception index	0.027	0.022	0.018
Overall Livelihood Vulnerability Index **SNP: 0.406** **GCA: 0.382** **KNP: 0.417**							

Source: Survey (2013)

6.4.3.2. Climate change vulnerability of transhumant herders

The overall climate vulnerability index was the highest in Khumjung and the least in Kalinchok (Table 6.7, Figure 6.11). Each of the three study sites was represented by the highest indexed value for one dimension (out of adaptive capacity, sensitivity and exposure). For Khumjung and Majhigaun adaptive capacity was almost similar. Following Khumjung which had the highest value for the exposure, Kalinchok was second and Majhigaun had the least value for this dimension (Table 6.7, Figure 6.11).

Table 6-7: Indexed values for different dimensions of vulnerability

Vulnerability components	Khumjung/ SNP	Kalinchok/ GCA	Majhigaun/ KNP
Adaptive capacity	0.392	0.482	0.398
Sensitivity	0.342	0.256	0.434
Exposure	0.321	0.232	0.21
Climate vulnerability index	0.686	0.232	0.643

Source: Survey (2013)

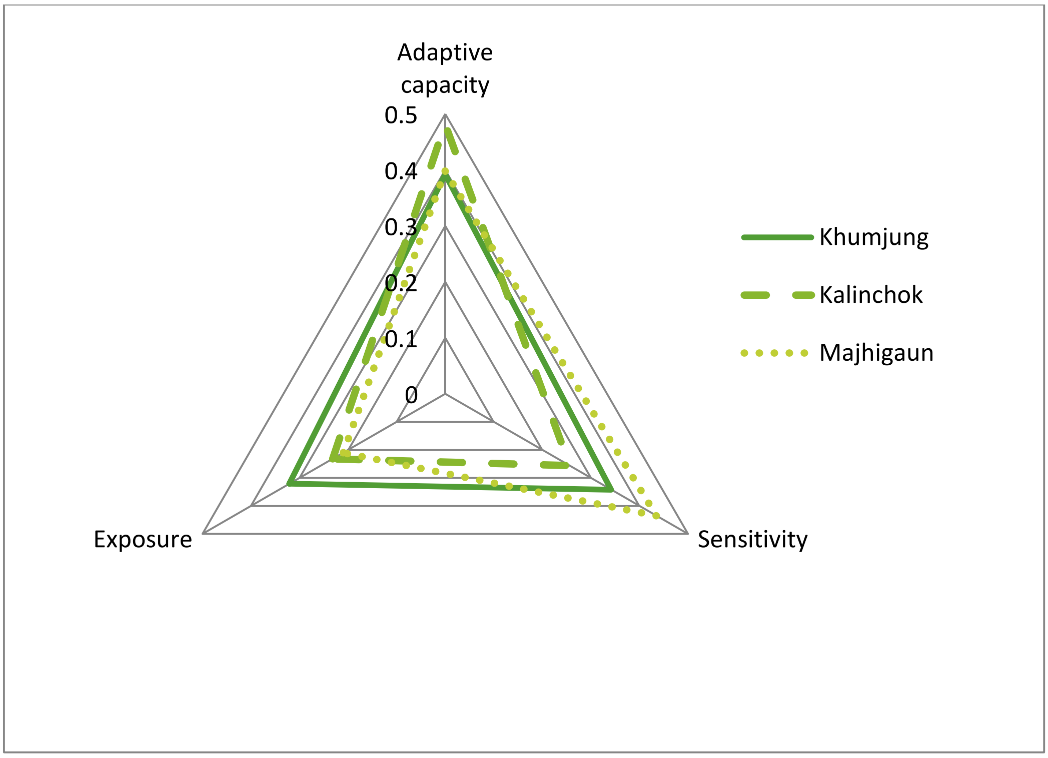

Figure 6-10: Vulnerability triangle diagram of the dimensions of CVI; **Source:** Survey (2013)

6.5. Major changes in the transhumance systems

6.5.1. Number of families involved in the transhumance systems

Transhumant herders perceived that the number of households (HHs) involved in transhumance has declined in all study sites (Table 6.8). In Khumjung, many HHs switched their profession to tourism related business. In Kalinchok, the numbers of

HHs who were involved in long distance movement heavily declined. The families involved in long distance movement were those who were rearing *chauri* and herding large flocks of sheep and goats. There were only 8 HHs practicing *chauri* rearing in Kalinchok VDC at the time of data collection. The main reasons for decline in Kalinchok were a decade (1996-2006) long political conflict (war) between Maoist and state, shortage of labour and grazing restriction by community forests. The number of *goths* inside KNP (Figure 6.12) showed that the number of families practising transhumance has continuously declined. The decline in numbers of families involved in transhumance in KNP largely coincided with the political conflict in the country.

Table 6-8: Major changes in transhumance in the study areas

Changes in	**Site**		
	Khumjung	**Kalinchok**	**Majhigaun**
No of families practicing transhumance	Decreased	Decreased (families rearing *chauri* heavily declined)	Decreased
Herd size	Decreased for many families but increased for few families	Decreased	Decreased
Herd composition	Nak/*chauri* before tourism, Yak/*jokpyo* after tourism	Number of *chauri* heavily decreased	Before conflict cattle, goat after conflict
Grazing areas	Few herders reach to distant rangelands	Distant rangelands at high elevation are abandoned and grazing areas at lower elevation are restricted due to CF	No change
Purpose of rearing livestock	Changed from livestock products to livestock as means of transport	Almost same (except no wool is produced from goats and sheep)	Almost same (but preference of goats is to generate cash)
Dependency on transhumance	Decreased	Decreased	Decreased
Involvement of young generation in transhumance	Decreased	Decreased	Decreased

Source: FGD (2013)

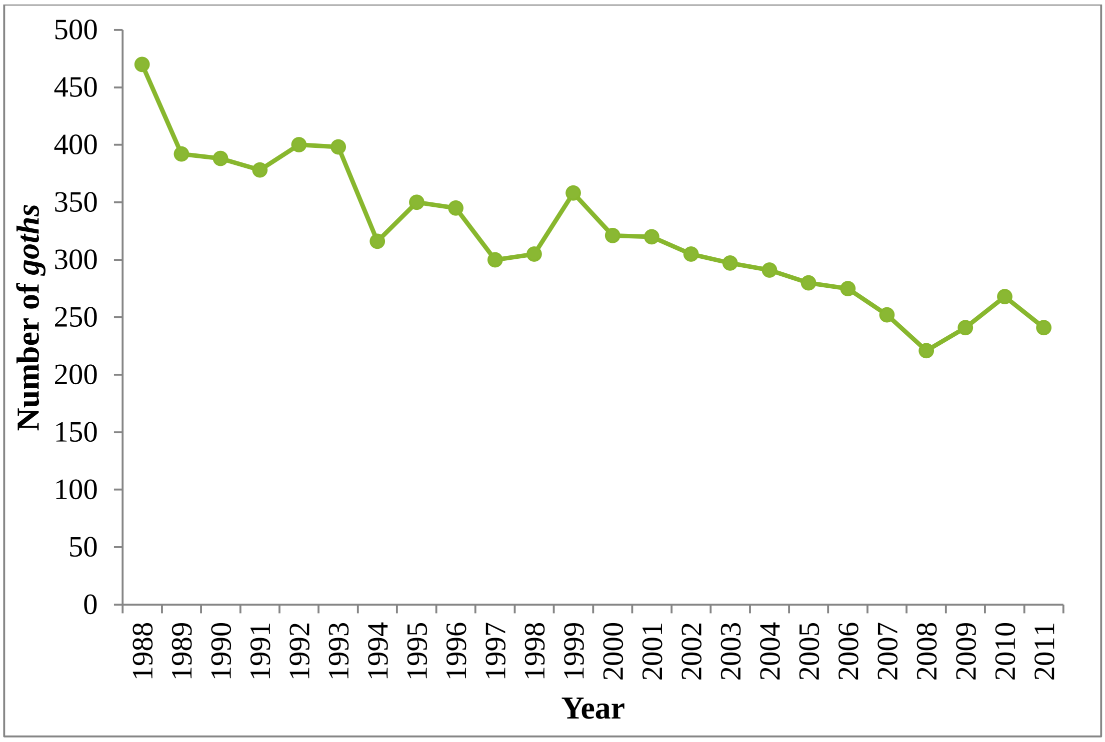

Figure 6-11: Total number of *goths* inside KNP; **Source:** KNP (2013)

6.5.2. Herd size and composition

Herders mentioned that the average herd size was generally found to be decreasing in all sites. The exception was that some HHs of Khumjung had maintained or even increased herd size due to the increasing demand for yaks to carry goods for tourists and hotels. The total number of livestock was almost stable in Khumjung (Figure 6.13) due to increased number of HHs, but herders mentioned that herd size has decreased. There was a decrease in the number of female livestock such as nak and *chauri* which were reared for dairy products in the past but the number of male livestock such as yak and *jokpyo* has increased (Figure 6.14) as their demand increased for the carrying of goods.

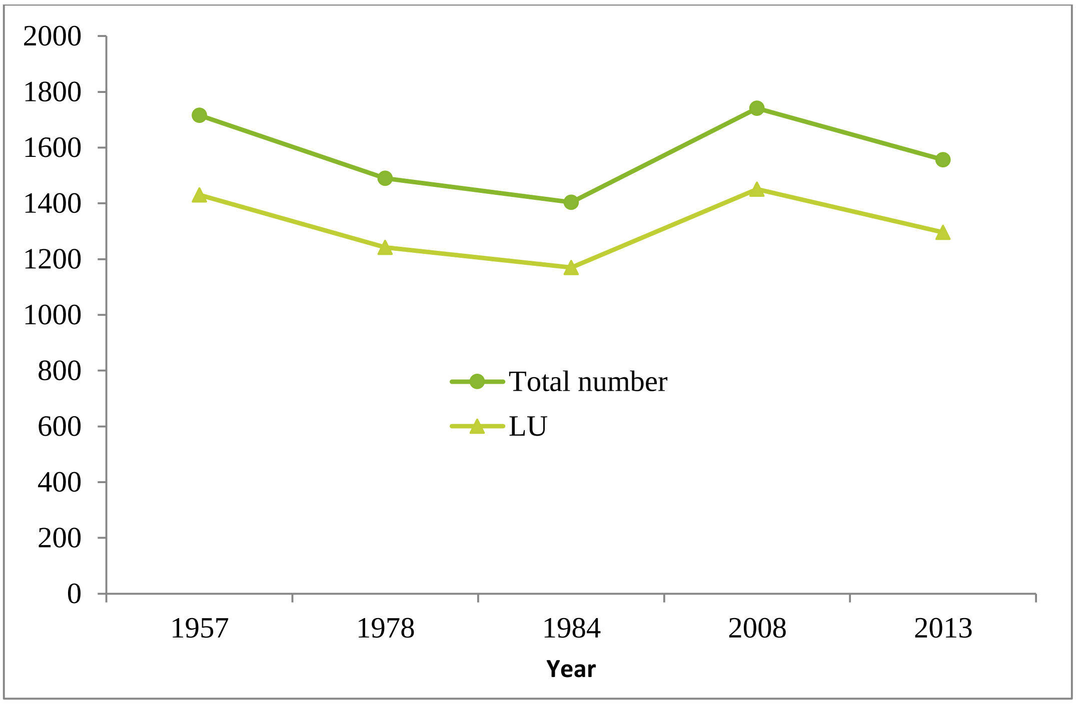

Figure 6-12: Trend of livestock in Khumjung VDC (**Source:** for 1957 (Fürer-Haimendorf 1975), for 1978 (Bjønness 1980), for 1984 (Brower 1992), for 2008 (Sherpa 2008), for 2013 (HH survey, 2013)

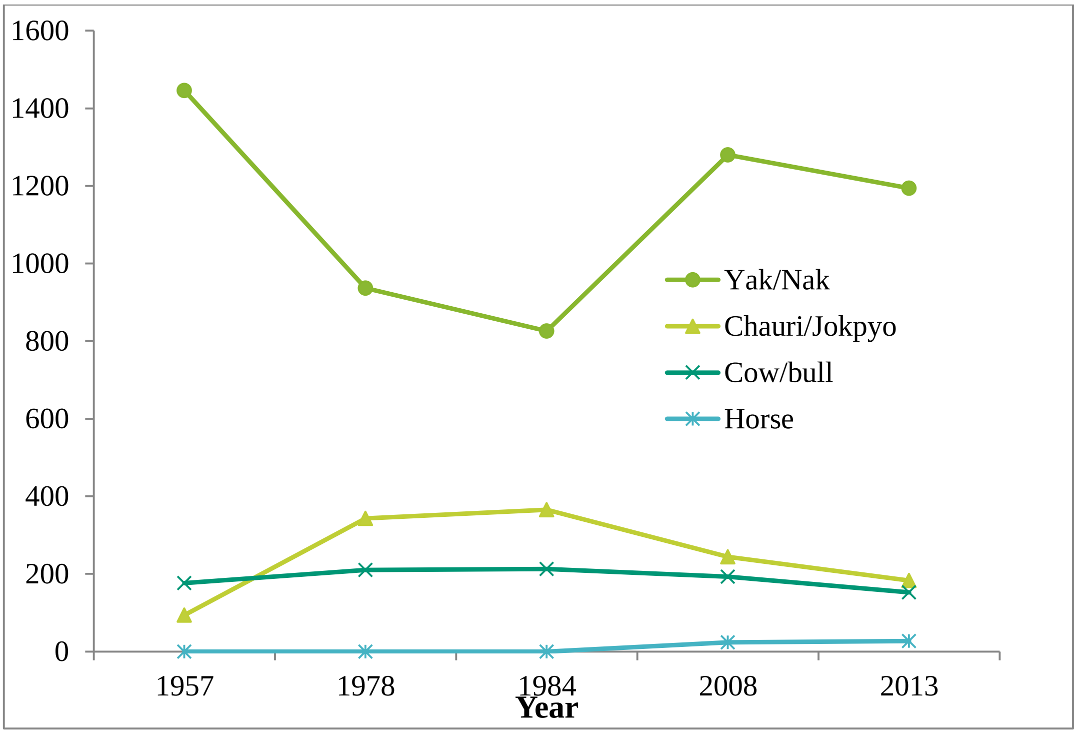

Figure 6-13: Trend of each livestock type in Khumjung VDC (**Source:** for 1957 (Fürer-Haimendorf 1975), for 1978 (Bjønness 1980), for 1984 (Brower 1992), for 2008 (Sherpa 2008), for 2013 (HH survey, 2013)

Herders mentioned that due to the decline in numbers of HHs rearing *chauri* in Kalinchok, the number of *chauri* has declined. The sheep rearing had vanished and there were very few HHs involved in keeping large flocks of goats. But the number of HHs keeping some goats in their herd in combination with cattle or buffaloes is increasing. The number of cows/oxen and buffaloes were almost stable or slightly declined.

From the FGDs, herders concluded that the herd size and total numbers of livestock has decreased as compared to the past in Majhigaun. They explained that the numbers of livestock rapidly declined during the Maoist insurgency period (1996-2006). The figure for KNP, where herders from Majhigaun also graze their livestock in summer season also showed a declining trend (Figure 6.15). The total number of livestock and total LU declined from the mid-nineties and remained at low level for more than one decade. Both of them increased after 2008. The total number of livestock seems to have attained the same level prior to mid-nineties. However, the figure for total LU is still very low. This is because the number of goats, relative to larger animals sharply rose after 2008 compared to other livestock types (Figure 6.16) because they need less initial investment and can be easily sold.

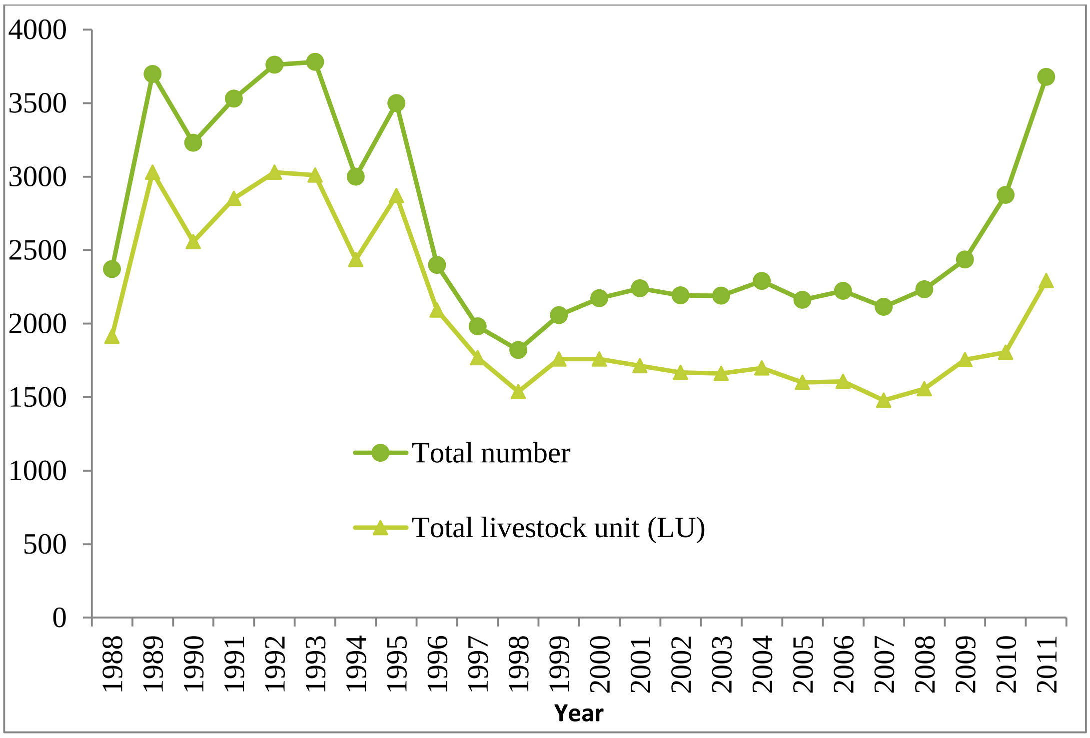

Figure 6-14: Trend of livestock in KNP; **Source:** KNP (2013)

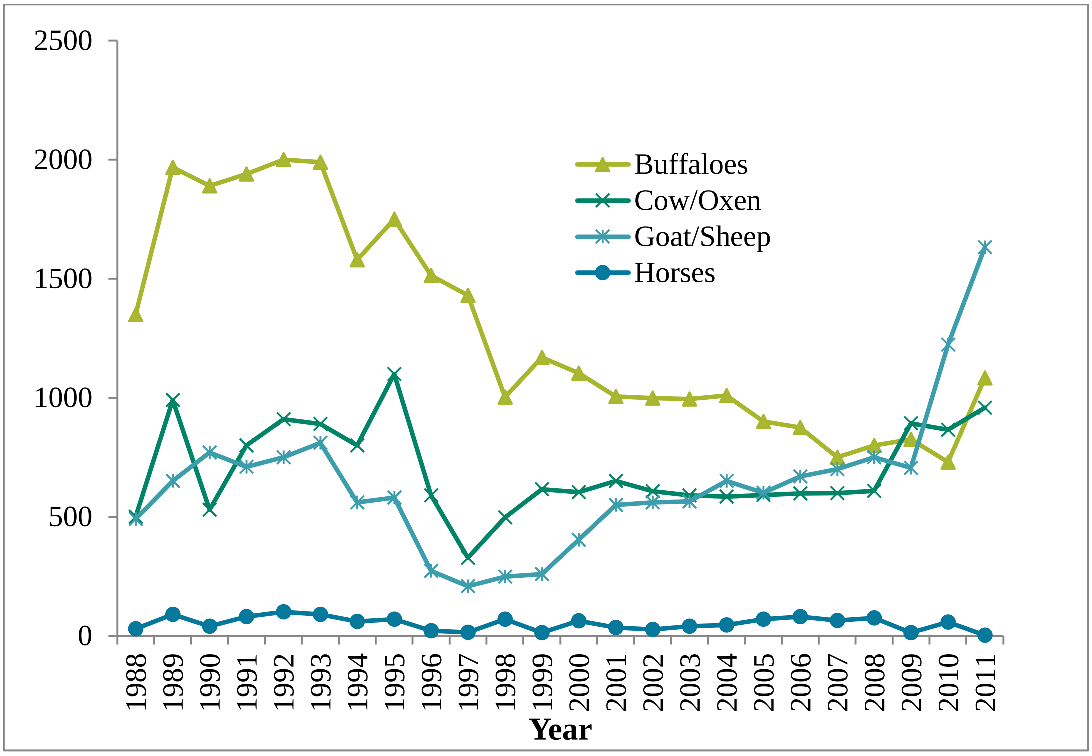

Figure 6-15: Trend of each livestock type in KNP; **Source:** KNP (2013)

6.5.3. Grazing areas and movement pattern

In Khumjung, very few herders reach the distant rangelands and the route and movement pattern has not changed since the *Nawa pratha* was responsible for fixing the movement date (departure and arrival) of livestock from/to village. In Kalinchok, the distant rangelands which were used by *chauri*, sheep and goats in the summer season were used by very few herders. Some rangelands are abandoned due to the drying of water sources (spring). The forests of lower elevations were converted to CFs and access to grazing for herders was restricted. This has increased dependency on private land and other accessible forests to the mid altitude areas. Herders of Majhigaun still use the all grazing areas inside parks which were used in the past but they had to pay grazing fees to the park and they had to follow the grazing duration inside parks defined by the park office. Herders mentioned they can graze relatively less time in the rangelands inside parks than in the past. Before KNP establishment, the movement date would be based on discussion among villagers.

6.5.4. Dependency on transhumance and social prestige of transhumance

Herders perceived that the dependency on transhumance livestock production has declined. In the past, animal husbandry and agriculture were the only livelihood activities and family income sources. Now, herders have diversified family's income sources in different ways. In Khumjung, 73% surveyed herders mentioned that their HHs income also comprises income from tourism related activities. Some members of herder's family were either operating tourism related business or engaged in mountaineering, guiding tourists or portering. In Kalinchok, the trend of overseas migration was high which had increased HHs income. This was also confirmed by the survey as one third of herders HH mentioned that they receive remittance (Table 4.6). In Majhigaun, youth seasonally migrated to Indian cities to earn cash and more than 55% of HHs surveyed received additional income from seasonal migration (Table 4.6). In addition, some people were also engaged in construction works (houses, buildings), jobs and other social works which were the additional income sources for the families. The increase in income has increased the capacity to buy (afford) food and services and reduced dependency of families on transhumance and other local production. Herders mentioned that imported foods were increasingly becoming more popular than locally produced foods in Khumjung and Kalinchok. The HHs owning large numbers of livestock were seen as wealthier and prestigious in the past. However, this system is now perceived as backward, difficult and more labour demanding, especially by younger generations.

6.5.5. Involvement of young generation in the transhumance systems

Herders from all the study areas have perceived that the involvement of younger generations in the transhumance systems has declined. Almost all herders found and met in rangelands or *goths* of all sites were above 50. The average age of the herders included in the survey were also above 50 (Table 6.9). There were many HHs in all study areas where members of the older generations were staying in *goth* looking after livestock, while younger people were living in permanent settlements.

Table 6-9: Gender, age and education of herders in the study areas

Characteristics of respondents	**Site**		
	Khumjung (n=37)	**Kalinchok (n=54)**	**Majhigaun (n=54)**
Gender	M=25, F=12	M=31, F=23	M=34, F=20
Average Age (years)	53.79	54.93	52.54
Average education (no of years)	1.84	1.19	1.46

The young people with whom I interacted during field study did not express interest in transhumance because they think that the practice is traditional, difficult and there is no return (income) from the transhumance except fulfilling dairy product requirement of HHs and passing time. Even the herders did not want to see their children doing transhumance in the future. Instead they are happy if they go to school, study well, and find other jobs. They want the younger generations involved in other activities, or going abroad which they think is an easier way to earn money and raise the socio-economic condition of HHs. Herders mentioned that there were no schools, so they used to engage in transhumance from their childhood. But the situation has changed now. The decline in involvement of the younger generation implies that there could be major structural changes in the transhumance systems when current herders retire.

6.6. Adaptation strategies of transhumant herders

The local adaptation strategies used by transhumant herders are given in table 6.10. Following the classification of Agrawal (2010), the strategies are classified under five adaptation types; mobility, diversification, storage, communal pooling and market (exchange). Seasonal movement of livestock and seasonal migration to cities are the strategies under mobility. Diversifications of livestock and crop, livestock feeding resources (grazing resources), and income sources were also found. The storage of grass, hay, crop residue, grain, seed and reservation of grazing land or fodder trees for special occasion are also practised. Communal ownership (for grazing not land entitlement) of high elevation rangelands, joint effort to repair trails and manage water sources, formation of formal and informal groups, groups decisions etc. are examples of strategies under communal pooling. These strategies help to develop a synergistic effort to deal with emergency situations. Herders were exchanging help, labour work, food and livestock products in cash or kind which derived mutual benefits. These local strategies of the transhumant herders spread risk across space, time and assets and enhance adaptive capacity.

Table 6-10: Adaptation type, strategies and the pathways for better adaptation

Adaptation type*	**Local adaptation strategies**	**Aims/outcomes**
Mobility	Seasonal movement of livestock at different altitudes	Helps to utilise grazing resources at different altitudes, avoid overgrazing, protect crops from livestock, spread risk over space
	Seasonal migration of labour (to different cities of Nepal and India	Diversify family income, spread risk over assets
Diversification	Diversification of herd (livestock)	Helps to meet different purpose at the same time, reduce loss/damage during epidemics, spread risk across different livestock (i.e. different asset)
	Diversification of livestock feed (grazing resources)	Helps to keep them in good condition during winter season and drought period
	Diversification of crop and vegetables	Reduce dependency and provide substitution when one crop or vegetables failed, and spread risk across different crops and vegetables
	Diversification of family income sources	Reduce dependency on one income sources and spread risks across different income sources
Storage	Storage of grass/hay	Helps to feed livestock during winter season
	Storage of crops residue	Helps to feed livestock during winter season
	Storage of grains	Helps to supplement feed for herders and lactating livestock

Adaptation type*	**Local adaptation strategies**	**Aims/outcomes**
	Storage of seeds	Reduce dependency on other families or organisations and helps to diversify crops in next cropping season
	Reserve some grazing areas and grass (or specific fodder trees) for busy time (crop plantating/harvesting time, festival time or for livestock delivery time)	Helps to feed livestock while herders are busy in other activities and while livestock need special care
Communal pooling	Communal ownership for high elevation rangelands (to graze in summer season)	Provide flexible boundaries and reciprocal use of rangelands, fair utilisation of grazing resources
	Distribution/division of summer grazing rangelands for herders from different village/districts	Division is mainly based on distance from the settlement that benefits all herders, provide flexible boundaries
	Joint effort to repair trails for livestock movement	Offer collective action which is difficult to accomplish at individual level
	Joint effort to repair water sources and division of available water resources	Offer collective action which is not possible to do at individual level
	Collective gathering and group's decision about livestock movement date from village to rangelands	Reduce conflict in the use of grazing resources, assist one another in difficult situations, can be benefited by same information
	Discussion with neighbour to move from one rangelands to another (within summer grazing rangelands)	Reduce conflict, can assist one another, combine herd while moving
	Join formal groups such as CFUGs, CAMCs, farmer groups	Helps to identify problems, exchange help, and equal and fair distribution of benefits
	Join informal groups (such as *chauri* herders groups, yak herders groups)	Helps to raise common issues with government and non-governmental organisations and ease fair and equitable distribution of resources
	Merge small herds of different families and send herders in rotation	This provides efficient utilisation of available labour force
Exchange/market	Exchange help during emergency situations	Helps to overcome emergency situations
	Exchange labour	Helps to fulfil labour force for more labour demanding activities
	Exchange livestock products with grains	Derived mutual benefits for herders and farmers
	Exchange draft animals (for ploughing) with wage labour	Herders family providing draft animals benefited from other labour hands while other families get draft animals to plough farm

Adaptation type*	Local adaptation strategies	Aims/outcomes
	Buy/sell livestock and livestock products	Helps to diversify income by selling or can diversify herd buying livestock
	Buy/sell grass/forage	Helps to feed livestock during grass/forage shortage
	Buy/sell breeding livestock (usually male livestock)	Not required to keep breed livestock (male) by all herders but get services from other herder (paying in kind or cash)

Source: FGDs, observation and informal talks with herders (2013), *Agrawal (2010)

6.7. Conclusions

Globalisation, conservation policies and practices, and climate change were studied as the pressure of change to the transhumance systems. Tourism and labour migration were considered as two factors under globalisation. Each of them was relevant in at least one study area. Even amongst transhumant herders, the livestock units (LU) was significantly different between the households (HHs) involved in tourism and those who were not. Similarly, the LU was significantly higher in non-migrants HH than in migrants HHs (migrant to other than India) in Kalinchok. Though, the LU was slightly higher in non-migrant HHs than for migrant (migrants to India) HHs in Majhigaun, it was not significantly different. Herders perceived that both tourism and labour migration have added pressure in two main ways; one by reducing labour availability and another by increasing HHs income.

The analysis of policies and laws relevant to conservation schemes in the study areas showed that the operational freedom of transhumant herders was affected by them. Power has been devolved to local users groups whether to allow grazing or not in CFs and CA. The provisions in state CF policies which can accommodate issues of transhumant herders were not implemented at local level. The provision to form CAMC following VDC boundary can exclude herders from other VDC in CA. In mountainous NPs (such as SNP), herders inhabiting parks are allowed to graze in designated areas and time. In KNP, where there were no settlements, the KNP regulation allows herders from surrounding areas to graze livestock for a specified time after paying fees to the park. The restricted access to grazing in NP for designated areas and time may not meet the requirements of the transhumant herders. Transhumant herders showed low positive perceptions and attitudes, and low levels of participation towards CF, CA and NP. However, they showed high level of expectations for transhumance grazing and related activities in the areas under those schemes. That is, they want access to resources and participation in managing those resources, but don’t believe they are getting those.

Temperature showed an increasing trend in all sites and the trends were higher for winter season than for summer season. The trend of rainfall was not consistent across sites. Herders perceived changes in bio-physical indicators in the study areas. The trends of key climatic variables (temperature and rainfall) and perceptions of herders towards changes in bio-physical indicators indicate that climate change has emerged as additional pressure to the transhumance systems. The vulnerability analysis showed that herders from all sites were vulnerable but for different reasons. The LVI was found highest for KNP whereas CVI was highest for SNP. The ‘health’ and ‘water’ had greater contribution for the highest LVI for KNP and ‘food’ and ‘natural disaster’ had greater contribution for the highest CVI in SNP. One of three dimensions of vulnerability namely adaptive capacity, exposure and sensitivity had highest value in one site. The SNP had the highest index value for exposure, GCA had the highest index value for adaptive capacity, and KNP had the highest indexed value for sensitivity.

There were changes in different aspects of transhumance systems in the study areas. Herders have perceived that the total number of HHs practicing transhumance has declined. This was also supported by the declining trends for number of *goths* inside KNP. Herders from all sites have perceived a decrease in herd size except few HHs in Khumjung. Herders have also perceived slight changes in herd composition which were also supported by the data in Khumjung and KNP. Across study sites, herders have perceived decrease dependency of transhumance and decrease involvement of young generations in the transhumance systems indicating that there can be further structural change in the transhumance systems after the retirement of current herders.

Transhumant herders have practised different adaptation strategies. Most of them were evolved historically to deal with environmental and resource variability and some of them were developed in response to contemporary pressures and recent changes in the systems. Some of these local adaptation practices might be useful for better adaptation to the systematic threats such as climate change.

Chapter 7 : Discussions of findings

7.1. Introduction

Results of the study were presented in previous chapters (4-6). The purpose of this chapter is to discuss the major findings of the study. This chapter is divided according to the order of results presented in previous chapters. First, results on social components of the social-ecological systems (SESs) are discussed. This includes transhumance systems in the study areas and their socio-economic and cultural significances. Second, the results on ecological components of the study are discussed. This covers the effects of transhumance grazing on plant species richness and composition in the Himalayan rangelands. Third, major drivers of change and pressures to the SESs are discussed. Global scale drivers such as globalisation (tourism and labour migration for instance) and climate change, national level drivers such as state conservation policies and practices, and political situation of the country, and local level drivers such as local biophysical characteristics and poverty are discussed in this section. Fourth, major changes in the SESs and likely social-ecological impacts are given. Finally, discussion about local adaptation practices to the changes and possible future scenarios of the transhumance systems are discussed.

7.2. Transhumance systems and their socio-economic and cultural significance

Findings on social systems of social-ecological systems (SESs) are discussed in this section. This covers contemporary transhumance systems in the study areas and their socio-economic and cultural aspects.

7.2.1. Livestock holding and herd diversification

The percentage of households (HHs) owning some kind of livestock and practising transhumance differed across sites. The proportion of households (HHs) having livestock (31.94% in Khumjung, 65.06% in Kalinchok and 80.81% in Majhigaun) in the study areas were less than the 95% of HHs owning ruminants in the mountains of Nepal, as previously found (Maltsoglou & Taniguchi 2004). It is generally expected that the proportion of HHs involved in livestock production increases with the increase in altitude in Nepal (FAO 2005; Pariyar 2008) because agricultural production is limited by the cold climate and short growing season at high altitudes. However, the proportion of HHs having livestock in Khumjung was low compared to two other sites though the Khumjung lies at higher altitude. It is likely that the growth of tourism in SNP attracted herders from Khumjung towards tourism related business (Sherpa & Kayastha 2009; Spoon 2013) and reduced the number of families involved in livestock production in that area.

The proportion of HHs practicing transhumance was 17.5% of those rearing some kind of livestock in Majhigaun, 21% in Khumjung and 40% in Kalinchok. The differences across sites were related to tourism, distance to rangelands from village and extent of agricultural production. Before the rise of tourism, almost all HHs in Khumjung had livestock and all of them would practice transhumance (Bjønness 1980). Tourism reduced both the number of HHs rearing livestock and those practicing transhumance. All livestock are still moved from villages to the high altitude rangelands in the summer season, but all HHs do not send herders. In Kalinchok, the rangelands used in the summer season were located at the shortest distances (4-5 hrs walk distance) from the villages compared to two other sites. Alhough, they could not be accessed on a daily basis, short distances from the village made it possible and easier for many HHs to move their livestock to the rangelands in the summer season leading to the highest proportion of HHs practicing transhumance in Kalinchok. The smallest herd size in Kalinchok (Table 4.1) also indicates that HHs with few livestock also practice transhumance in that site. The proportion of HHs practicing transhumance was the least in Majhigaun where settlements were at lower elevation and crop production was high compared to two other sites. Many HHs preferred crop production, keeping few livestock in their HHs, feeding them agricultural residues and grazing around the settlement rather than practicing transhumance.

Herders from all sites had combined different types of livestock (Figure 4.2 and Figure 4.3). The main factor affecting herd composition was altitude (which is directly related to climate). The yak/nak, which was the dominant livestock type in Khumjung, was absent in two other sites. Yak cannot tolerate higher temperature and do not go below 3000 metre above sea level (m asl) (Dong *et al.* 2009b). This signifies how the natural environment is responsible in the selection of livestock types and ultimately to shape the composition of herds (Sutton & Anderson 2014). In addition to the altitude or climate, herd composition was shaped by the demand of livestock for a special purpose. For example, yaks and *jokpyo* were in an increasing trend whereas naks and *chauri* were in a decreasing trend in Khumjung. This is because males are preferred to females as pack animals (Padoa-Schioppa & Baietto 2008). As there were more agricultural activities in Kalinchok and Majhigaun, cows/oxen were kept in large numbers for manure and draft power to prepare agricultural land. The absence of goats from Khumjung is an example of how state conservation programmes can affect herd composition because goats were banned inside SNP as they are supposed to graze more destructively (*SNP Management and Tourism Plan* 2007).

The diversification of the herd has multiple benefits. First, each type of livestock is reared for a special purpose (Table 4.3). Combining different types of livestock in a herd helps to fulfil various livelihood needs (Megersa *et al.* 2014a). Second, the diversification of herds also helps to spread risk across livestock types and reduce risk and damage during epidemics and extreme weather events (Mishra *et al.* 2003). Mixed herding also helps to reduce vulnerabilities to climate change (Altieri & Nicholls 2013; Megersa *et al.* 2014a), increasing food diversity and security (Megersa *et al.* 2014b). Finally, diversification of herds helps efficient utilisation of grazing resources available at different locations and altitudes because all grazing areas are not equally accessible to all livestock types. For example, goats prefer shrubs, they are good climbers and can graze in steep areas where cattle cannot. In Khumjung yaks/naks usually grazed in higher elevation whereas other cattle graze in lower elevation. This type of niche differentiation and mix herding helps to reduce inter-species competition on the one hand and avoids overgrazing on the other hand (Cromsigt *et al.* 2009).

It can be concluded that tourism, distance to rangelands (mainly used in summer seasons), and extent of crop production (differs with altitude in Nepal) were the major factors explaining the differences in proportions of HHs practicing transhumance in the study areas. The herd compositions were shaped by altitude and climate, and their demand (for instance for agriculture and tourism). The herd diversification had helped to achieve multiple services and at the same time it reduces risks during outbreaks of diseases, climate change and also helps to avoid overgrazing.

7.2.2. Seasonal movement of livestock, reason for movement and its advantages

Seasonal movement of livestock is the key feature of the transhumance system. Transhumant herders were found to practice vertical seasonal movement in the study areas (Figure 4.4) whereby they ascend to the rangelands located at high altitude in the summer season and descend to the villages in the winter season. Similar movements of livestock in the Himalayan (Moktan *et al.* 2008; Namgay *et al.* 2013; Omer *et al.* 2006; Pawson & Jest 1978) and other mountains (Akasbi *et al.* 2012) have also been reported. The seasonal movement of livestock is an ecological necessity as well as a herder's rational approach to use grazing resources (Adriansen 2008).

The three reasons for practicing transhumance which were ranked top by the transhumant herders in all sites were 'in search of grazing resources', 'to be safe from hot and cold temperature' and 'to avoid overgrazing in the grazing lands'. Considerable seasonal variation in grazing resources and climate at different altitude occurs in the Himalayas and transhumant herders respond to those variations and natural vegetation cycles by seasonal movement of livestock. The alpine and sub-alpine rangelands of the study areas are covered by snow in the winter season and grasses start to grow when snow melts and are grazed in the summer season. The winter grazing areas mainly comprise harvested agricultural fields, forests and river banks in the vicinity of settlements whereas the summer grazing areas lie in high altitudes where *goths* are located.

There are a number of benefits from the seasonal mobility of herds. First, the mobility helps to balance and adapt to resources and environmental variations at different altitudes. Second, moving livestock to the high altitudes in the summer season following the seasonal calendar also helped to reduce crop damage by domestic livestock as major crops were grown near permanent settlements in this season (Chaudhary *et al.* 2007). Third, the mobility of herds spreads risks across larger spatial scales and reduces vulnerability to the systematic threats such as climate change

(Brottem *et al.* 2014; McCarthy & Di Gregorio 2007). Finally, from the resource management perspective, this system establishes a rotational grazing pattern which distributes livestock impact over time and space, and avoids overgrazing (Brower 1992). The absence of livestock allows regeneration of grasses and prevents overgrazing. Therefore, movement of livestock in transhumance is a traditional rational approach for the management of the rangelands as argued by Dong *et al.* (2007).

Literatures (Bauer 2000; Bhasin 2011; Moktan *et al.* 2008) suggest that the movement of livestock in the Himalayas was also to make the selling of livestock and livestock products easier, and to purchase food and other products, and combine timing of other livelihood options such as collection of medicinal plants in the high altitude. However, they were found less applicable in the study areas. Other motivational factors such as engaging family members in off-farm activities, schooling options for children, reducing transportation cost, avoiding animal parasites from transhumance are also described (Akasbi *et al.* 2012; Namgay *et al.* 2013). But they were not found in the study sites because all family members were not moving with livestock in the study areas.

7.2.3. Importance of transhumant livestock production to the households economy

Livestock production was one of the major sources of herders' households (HHs) income in study areas (Table 4.7). This finding corresponds with the previous studies suggesting that animal husbandry is the dominant facet of subsistence economy in the mountainous region of Nepal (Bauer 2004; Pawson & Jest 1978). The contribution of livestock to total gross domestic product (GDP) is not reported separately by Nepalese economic surveys but it is reported in combination with agriculture where both of them contributed about 35.36% of the total GDP in the fiscal year 2011/12 (*Economic Survey* 2013). FAO (2005) estimated that livestock contribute about 11% of the total GDP of Nepal. The figures found in this study were much larger than the national figure due to two reasons. First, all of three study areas lie in the mountainous area where agricultural production is limited due to cold climate, short growing season and poorly developed soils. Second, HHs practicing transhumance were purposely selected and surveyed for this study. The HHs practicing transhumance generally own more livestock compared to other HHs within the study areas and they are more dependent on livestock production. However, the national figure includes all population including those from urban areas where people do not rear livestock.

The variation in the contribution of livestock production to total HHs income across sites with its highest contribution in Khumjung supports the argument that relative importance of livestock production is greater in high altitude (Abington 1992; Maltsoglou & Taniguchi 2004). On one hand, the low crop diversity and production due to cold climate in Khumjung increased the contribution of livestock production.

On the other hand, the use of livestock in tourism helped to increase income from livestock. In Khumjung, livestock such as yaks and *jokpyos* are hired to carry the baggage of tourists and one such pack animal can earn more than double that of a porter (Sherpa & Kayastha 2009). This helped to maintain or even raise income from livestock for those HHs keeping yaks and *jokpyos*. In Kalinchok and Majhigaun, the contribution of livestock was second to the agriculture because the crop production was high as they are located at lower elevation than Khumjung. Moreover, there was no tourism in Kalinchok and Majhigaun and the livestock and their products were mainly used for subsistence purpose. For many HHs however, remittance has emerged as a new source of HHs income as they have their family member working in other countries.

7.2.4. Mutual benefits between transhumance and crop production

Crop-livestock interactions differ along the agricultural intensification gradients (Erenstein & Thorpe 2010). Crops and livestock are more specialised in developed countries where the intensification and commercialisation of the agricultural systems have weakened crop-livestock interactions (Erenstein & Thorpe 2010). However, mixed crops-livestock systems tend to domainate in developing countries (Wright *et al.* 2012). The integration of crop and livestock is well developed in the small-scale agriculture of Nepal where complementary relations between crop and livestock production exist (Devendra & Thomas 2002; Yadav 1992).

In all study areas, transhumance livestock production was integrated with crop production and they were inseparable to each other. The use of manure from cattle where there is no option/availability of chemical fertilizers, and the use of cattle as draught power in agricultural field where there was no access to modern technology were the examples for how livestock contributes to the agricultural production. The use of draught animals in agriculture which was common in the study areas, occurs in more than 50% of cultivated areas of the world (Ramaswamy 1998). The use of crop residues, stubble, husk and grain to supplement cattle’s feed for instance were supporting livestock. Although the contribution of crop residues is less in mountains compared to Terai (NARC 1996), the use of such agricultural by-products helped to lessen the severity of winter bottleneck when there is severe shortage of grasses which was also described by previous scholars in other regions, (Bell *et al.* 2014; Letty & Alcock 2013) and the use of manure allows circular resource flow and reduces external input for crop production (Erenstein & Thorpe 2010). It has also been reported that the integrated farming systems outperform normal or commercial farming systems in different dimensions such as food security, environmental function, economic function and social function (Tipraqsa *et al.* 2007).

In the transhumance systems of the study areas, the integration of crops and livestock production was even wider and extended to beyond herder’s household level. This is because some farmers who were not rearing livestock were found to invite transhumant herders to build temporary stables in their fallow land after harvesting crops. Similar arrangements between farmers of low altitudes and transhumant herders of high altitudes also exist in other Himalayan countries such as India (Bhasin 2011) and Bhutan (Namgay *et al.* 2013). Farmers benefit as the fertility of soil increases for the next cropping season and herders benefit through feeding crop residue and stubble in the winter which is the major grass deficit season of the year. Farmers who did not own draught animals were found to hire draught animals for cash, kind or by human labour which provided mutual benefits for farmers and herders.

The integration of transhumance livestock production with crop production and mutual benefits between them can add to the sustainability of the systems because it may not be easy for those HHs practicing these activities to switch completely to other livelihood activities. A mixed strategy implies diversified livelihoods, it reduces risk spreading across different enterprises (Guillet *et al.* 1983; Wright *et al.* 2012) which is considered important to combat contemporary threats such as climate change. As transhumance is integrated with agricultural production, it helps circular resource flows between livestock and crops and reduces the reliance on external inputs (Erenstein & Thorpe 2010; IFAD 2010). Such mixed strategies also play a significant role for global food and nutrient security (Herrero *et al.* 2010; Wright *et al.* 2012).

7.2.5. Traditional knowledge and culture associated with transhumance systems

Traditional knowledge, practices, institutions, and culture co-evolve with specific ecosystems (Pretty 2011; Pretty *et al.* 2009). They constitute part of the social system in the study of traditional SESs. Transhumant herders in the study areas have traditional knowledge and practices (see section 4.3.3) evolved from the generations of experiences and transhumance systems have evolved as a socio-cultural tradition. Herders use knowledge about the distance to rangelands, terrain condition, productivity, spatial-temporal distribution of grazing and water resources, and prevalence of pests and diseases while dividing grazing ownership over rangelands that are used in the summer season. There are several studies (Fernández-Giménez & Fillat Estaque 2012; Ghorbani *et al.* 2013; Oba & Kaitira 2006; Waudby *et al.* 2013) from different parts of the world reporting herders use of different indicators related to animals, plants and terrain to assess the conditions and productivity of the grazing areas. The knowledge about these indicators were generated from centuries of experience and were transmitted to the succeeding generation (Ghimire *et al.* 2004).

Traditional knowledge and practices were helpful in defining rangelands ownership (for use) and management, guide herd movement and conflict resolution in the study areas. They were useful in organising herders for rangeland management and making decisions for when and where to graze different types of livestock. The *nawa pratha*, a historically evolved a unique livestock management system in Khumjung was regulated by the Sherpa people. Stevens (1993) described five goals of *nawa pratha* which were protecting crops from livestock, protecting winter grazing areas, protecting fodder in hay fields and wild areas where grass is cut, restraining wild grass cutting until they reach maturity, and rotational grazing across different zones. Such mechanisms eventually prevent rangelands degradation i.e. from a 'tragedy of commons' (Hardin 1968).

Transhumant herders also use different strategies to make their daily activities efficient and easier. Such strategies gradually evolve in pastoral societies by generations of trial and error by herders and transmitted from generation to generation (Namgay *et al.* 2013). The division of summer grazing areas based on distance from settlements made it less time consuming for all herders to reach those areas. The castration of male livestock to make them less violent, use of herder's calls (particular word and sound of herder) to gather livestock in the evening and to direct herds toward water resources, use of salt to bait livestock and use of bells on the neck of senior livestock to know the location of the herd were some of the strategies of herders in the study areas. In addition to making herders' daily activities easier and efficient, these locally developed strategies might have the potential to assist in distributing and managing livestock and livestock grazing pressures in the rangelands indicating their ecological significances (Fernandez-Gimenez 2000; Ghorbani *et al.* 2013).

Traditional ecological knowledge, practices, beliefs and cultures can contribute to building the resilience of traditional systems and contribute to their sustainability (Berkes, Colding, *et al.* 2000; Fraser *et al.* 2015; Gómez-Baggethun *et al.* 2013; von Glasenapp & Thornton 2011). The integration of such knowledge with novel science and technologies can effectively contribute to livestock and rangeland management (Knapp & Fernandez-Gimenez 2009; UNEP-WCMC 2002). However, traditional ecological knowledge, practices, cultures and beliefs embedded in traditional SESs such as transhumance are declining. Due to the declining involvement of the younger generation in traditional farming systems, they might have less traditional knowledge compared to the people of older generations (Ayantunde *et al.* 2008; Oteros-Rozas *et al.* 2013a). In the study areas, herders have perceived that the involvement of the younger generation has declined over time which suggests that the integrity of traditional knowledge and practices could further decline when current transhumant herders retired from the systems.

7.3. Ecological roles of transhumance grazing

In this section, the ecological roles of transhumance grazing in the Himalayan rangelands are discussed. First, how livestock distribution and grazing pressure differs from the *goths* (livestock assembly points) to the surrounding area is discussed. This is followed by the patterns of plant species richness and composition from the *goths* to the surroundings. Finally, management implications of the findings and limitations of the study are given.

7.3.1 Grazing gradient along the distance from *goth*

The spatial variation in livestock distribution develop a grazing disturbance gradient from the livestock assembly points such as watering point, summer farms and *goths* (Aryal 2010; Ghimire *et al.* 2006; Haynes *et al.* 2013; Riginos & Hoffman 2003; Vandvik & Birks 2002a). The distribution of livestock in the rangelands is affected by physical (e.g. slope, terrain, availability of water sources), biological (e.g. availability of grazing resources, types and quality, social behavior of livestock) and managerial factors (Bailey *et al.* 1996). The foraging behavior and distribution of livestock is also influenced by spatial memory, visual clues and social learning (Launchbaugh & Howery 2005). The distributions of grazing surrogates such as dung and trampling indicate distribution of livestock in the rangelands. The level of dung and trampling generally decreased with the increase in distance from *goths,* however the trend was not always linear (Figure 5.1 and Figure 5.2). As this study covered limited distance from *goths,* the managerial factors and social behavior of dominant livestock were found important in the study areas. Gathering livestock at the *goth* in the evening and releasing them from *goth* in the morning on a daily basis increased grazing intensity near *goths* and led to the development of grazing gradient outwards from *goths*.

The dominant livestock type (yak/nak in one site and cow/oxen in the other two sites) had very similar social behavior. When livestock were released from *goth*, most of them soon urinated and excreted (personal observation) which enriches nitrogen in the soil and this favors ruderal and unpalatable species in the vicinity of *goths*. Livestock move quickly to cross this core area (termed a sacrifice zone by Peper *et al*. 2011) with ruderal and unpalatable species and avoid the odor of urine and excreta. Once they cross this core zone, the rate of movement slows when livestock start grazing. With the increase in time spent by livestock after crossing the core area, there is again a slight increase in grazing intensity which gradually declines thereafter. Figure 5.2 suggests that these core areas extend to between 100 m to 200 m distance from *goth*. The different pattern where there is minimum grazing at 200m in SNP (Figure 5.2) is related to the highest shrub cover at that distance. This is because shrubs can obstruct grazing accessibility to the livestock and reduce grazing intensity (Callaway *et al.* 2005; Schöb *et al.* 2013).

The dominant livestock types yaks/naks and cows/oxen predominantly feed on graminoids and they have considerable diet overlap (Mishra *et al.* 2004). The similar grazing preferences of yaks/naks and cows/oxen were also observed in the studied rangelands. Generally the hoof area of herbivores scale up linearly with body mass resulting in almost the same level of hoof pressure for different herbivores (Cumming & Cumming 2003) but the size of the area trampled differs with livestock type. However, the dominant livestock types in our study sites might have similar trampling effect as they had hard hooves and similar hoof sizes.

7.3.2 Variation in species richness across sites

The altitude was the main factor for the difference in species richness across sites. All studied rangelands and sampling sites in Sagatmahta National Park (SNP) were in higher altitudes than in Gaurishankar Conservation Area (GCA) and Khaptad National Park (KNP) and both the lowest α-diversity (Figure 5.3) and the lowest total numbers of species at each distance category (Figure 5.5) were recorded in this site. According to Lomolino (2001), the species richness generally decreases with the increase in altitude. In Nepal Himalaya, there is an increase in species richness with altitude until 1500 m asl, little change in species richness in between 1500 to 2500 m asl and a decrease from 2500 m asl (Grytnes & Vetaas 2002). This pattern of species richness with altitude is explained in terms of the hard boundaries at both extremes of mountains for species occurrence and mid-domain effect (Colwell & Hurtt 1994; Grytnes & Vetaas 2002). This is also related to the declining species pool and productivity with altitude (Bruun *et al.* 2006) and existence of ecotone (transition zone) between vegetation types.

7.3.3 Species richness pattern with distance from *goth*

The α-diversity and the total number of species per distance category were highest at mid distance compared to near or far from *goth* in all sites. These findings support the patterns suggested by the intermediate disturbance hypothesis (Connell 1978; Grime 1973) and are consistent with previous studies (Pavlů *et al.* 2003; Zhang & Dong 2009). As discussed earlier (section 7.3.1), the distance from *goth* represents a grazing disturbance gradient with maximum grazing pressure very close to the *goth* and minimum grazing far away from *goth*. The areas adjacent to livestock assembly points such as *goths*, summer farms and watering points are subjected to high grazing intensity that reduces plant species richness in such areas. While moving away from *goths*, species richness started to increase, peaked at some distance and remained stable or slightly dropped. There are many studies reporting remarkably low numbers of species very near to the livestock assembly points (Brooks, *et al.* 2006b; Landsberg *et al.* 2003; Preston *et al.* 2003). As we move away from such assembly points, the grazing intensity decreases whereas species richness increases and peaks at some distance and starts to drop when there is no or minimal grazing.

Although the maximum species richness was found at mid-distance from *goth* in all sites, the distance at which maximum number of species per plot occurred was different across sites. It was 200, 400 and 600 metre from *goth* for SNP, GCA and KNP. This variation may be somewhat related to factors that create different levels of accessibility to livestock for grazing. One of the prominent factors among the studied variables was the percentage of shrub coverage. In SNP, the highest number of species at 200 m distance from *goth* was also related to the highest percentage of shrub cover at that distance category (Figure 7.1).

This is because shrubs provide refuge for many palatable species and protect them from grazing (Aryal 2010; Callaway *et al.* 2005; Howard *et al.* 2012). The effect of shrubs could be negative (competition) in absence of grazing to positive (facilitation) with increasing grazing intensity (Graff *et al.* 2007; Sircely & Naeem 2013). The facilitative species could be less protective when grazing pressure is high (Smit *et al.* 2007). Osem et al. (2007) reported that grazing decreased species richness and biomass of annual plants in open patches but it increased species richness under canopy.

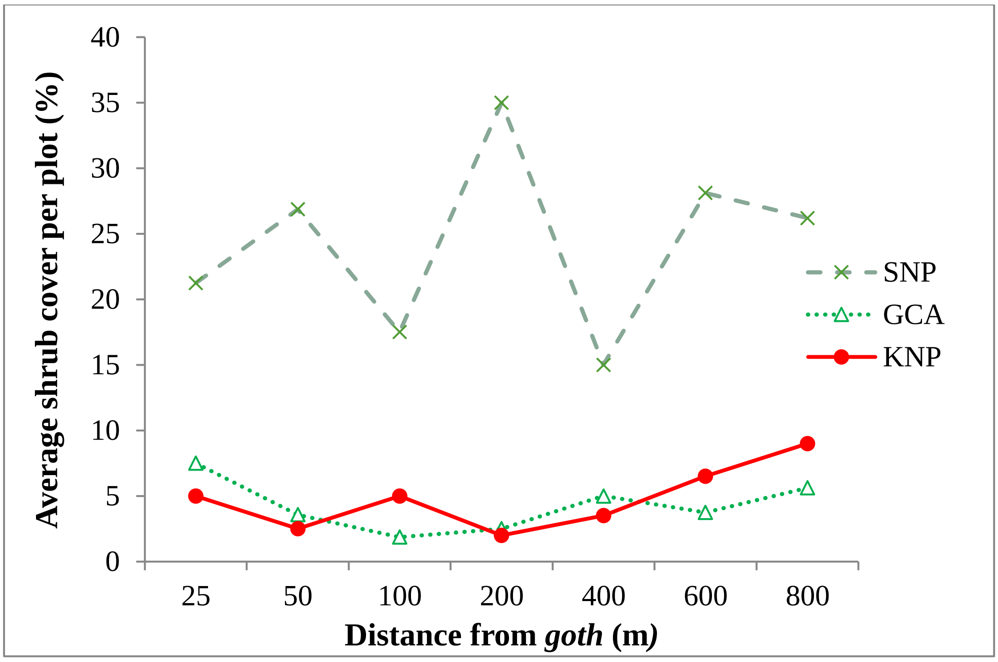

Figure 7-1: Average percentage shrub cover at different distance from *goth*

The pattern of the total number of species per distance category was similar for all sites i.e. it was highest at 600 metre from *goth* in all the cases (Table 5.2). There was a sharp rise in the mean number of species per plot and the total number of species per distance category up to 200 m distance (Figure 5.4, Figure 5.5) which might be due to high livestock (grazing) pressure up to 200 m from the *goth*. There are many studies (Dorji *et al.* 2013; Peper *et al.* 2011) reporting low number of species very close to the livestock assembly points and a dramatic rise in the number of species with the increase in distance from such points.

7.3.4 Vegetation environment relationship and species composition

A high species-environment relationship in Canonical Correspondence Analysis (CCA) (Table 5.3) suggests that the majority of the variation in the species composition was captured by the measured environmental variables in all study sites. Unexplained variation in the data set may be due to the existence of other unmeasured environmental variables (Vandvik & Birks 2002a) or due to statistical reasons. The interpretation of variation expressed as the fraction of total inertia may sometime underestimate ratio (Økland 1999), but it is highly useful to know the relative contribution (importance) of the measured environmental variables (McIntyre *et al.* 2003; Økland 1999; Vandvik & Birks 2002a).

Canonical Correspondence Analysis (CCA) revealed that altitude, soil moisture content and distance from *goth* were the variables significantly explaining the floristic variance in all sites (Table 5.4, Figure 5.6 to Figure 5.8). Some environmental variables were important in one site but not in others and the variances explained by the same factor were also not equal in all sites. These findings are supported by the fact that biotic communities or the species composition of an area is influenced by many factors. Both abiotic factors (Duprè *et al.* 2010; Knief *et al.* 2010; Polley *et al.* 2012) and management variables (Deckers *et al.* 2004) are important.

There was a gradual change in the species composition in response to different environmental variables. Considerable variation in the species composition was observed near to, and far from *goths* within 800 m distance from *goths*. Some species that were grazing tolerant or invaded overgrazed areas were abundant near *goths*. The increased abundance of nitrophilous species such as *Rumex nepalensis*, *Plantago majors* and *Ranunculus brotherusii* near *goths* might be related to increased nitrogen level in the soil due to urine and dung of livestock (Ponel *et al.* 2013). The presence of rare species such as *Aconitum spicatum*, *Allium wallichii*, *Rheum nobile* and *Dactylorhiza hatagirea* (Shrestha & Joshi 1996) at mid and farther distances (within 800 m transect) from *goths* suggest that the transhumance seasonal grazing has not threatened these species.

The increase in distance from *goths* in the Himalayan rangelands represents a grazing disturbance gradient. *Goths* that were used in seasonal grazing create unique floristic assemblage. The core areas near *goths* had comparatively low species richness where nitrophilous and grazing tolerant species were common. However, mid and further distances from *goths* within 800m transects had greater species richness as well as rare species showing that transhumance grazing has not threatened those species. The degradation of rangelands and reductions in biodiversity which were the main reasons for encouraging the cessation of transhumance grazing were not detected.

7.3.5 Management implications

The findings of this study contribute ecological information that can be used to inform rangeland management and biodiversity conservation policies and practices in the Himalayan rangelands. The lowest species richness and abundance of unpreferred species near to the *goths* suggest that the grazing had adverse impacts on native vegetation near *goths*. The highest species richness and occurrence of rare species at mid- and further distances from *goths* within 800 m distance suggest that light grazing promotes species richness in other zones and such grazing did not appear to affect rare species. The minimal effect of grazing suggests that policies and practices need to seek a balance between these ecological impacts and the socio-economic impacts on herders, should this practice be terminated. Future research could test the effects of different lengths of time spent at each *goth* and the effects of different herd numbers or combinations of species to determine optimal transhumance patterns that minimize ecological effects while also maintaining the socio-economic benefits of this customary practice.

7.3.6 Limitations

The rugged terrain and heterogeneous biotic communities offer some challenges and limit the study of grazing disturbance gradients in mountainous regions. There is a possibility that factors other than grazing might affect vegetation patterns. The effect of livestock grazing on species richness and composition through this approach can be better explored in the areas with uniform terrain and similar vegetation. Due to these limitations, we sampled plant species only up to 800 m from *goths* that represent livestock assembly points in the uniform land features and similar vegetation (Peper *et al.* 2011). The pattern of plant species richness and composition in response to grazing could be explored more precisely by establishing permanent plots with grazing and grazing exclusion (Good *et al.* 2013; Metzger *et al.* 2005) or developing experimental plots with different grazing treatments (Humphrey & Patterson 2000) in such mountain landscapes. However, these approaches require a long time-frame for monitoring and evaluating impacts.

7.4. Drivers of change to the transhumance systems

In this section major drivers of change to the transhumance systems are discussed. The drivers are classified as global/regional, national and local (Figure 7.2).

7.4.1 Global and regional level drivers

7.4.1.1 Globalisation

Globalisation has emerged as a key feature of the social-ecological systems (Young *et al.* 2006). As noted earlier (in section 2.3.2), there is no uniformity in the definition and interpretation of globalisation and it involves a complex set of phenomenon. In the Himalayas, globalisation has manifested in different ways and has brought both risks and opportunities (Jodha 2005a). Due to constraints such as inaccessibility and fragility, the higher Himalayas remained isolated from the external world. However, globalisation has breached such isolation in many areas. The influence from the growth of tourism and labour migration for instance are discussed under globalisation.

Out of three sites considered in this study, Khumjung (SNP) was a tourism dominated site. Even among households (HHs) of transhumant herders, the mean livestock units (LU) significantly differed between herders with or without family members involved in tourism. The growth of tourism has discouraged transhumance in different ways. First, tourism offered additional livelihood options whereby many families switched

their profession from animal husbandry to tourism related business. Second, it created labour shortages for the family because tourism attracted labour for mountaineering, guiding and portering. Third, tourism has diversified livelihood options and income sources thus reducing the dependency of HHs on traditional systems. The integration into market economy altered the way local people interact with the landscape such as from herding and farming to tourism (Spoon 2013). Fourth, tourism has changed the purpose and demand of livestock rearing. The demand for female livestock such as naks and *chauri* which were reared for dairy products decreased whereas the demand for male livestock such as yak and *jokpyo* which can be used to carry baggage of the tourists has increased (Keiter 1995; Padoa-Schioppa & Baietto 2008; Sherpa & Kayastha 2009). The changes in livestock number and composition were high in the settlements that lie near trekking routes compared to other areas located farther from trekking routes (Sherpa 2008).
Although many HHs have abandoned livestock production, some families in Khumjung have maintained herd size to use livestock for tourism purposes. They have increased the number of male yak and *jokpyo* in the herd and used them to carry baggage of tourists. One animal can earn double that of a porter in a day which encouraged some people to rear those livestock. This indicates the possibility of integration of transhumance with tourism.

Many scholars (Nepal & Nepal 2004; Padoa-Schioppa & Baietto 2008; Spoon 2013) have studied the social-economic and environmental implications of tourism in SNP (of which the Khumjung is a part). Some of the positive impacts of tourism reported were additional income opportunities, diversification of livelihood options and an increase in HH’s income. Similar effects of tourism were also reported in other mountainous areas of Nepal such as in Langtang (McVeigh 2004) and Manang (Subedi 2007). The diversification of livelihood options and income sources help to reduce vulnerabilities to the systemic threats such as climate change. However, tourism in the mountainous areas of Nepal is seasonal and livestock rearing is the mainstay of herders. Furthermore, it can be difficult to balance the economic benefits of tourism with social and environmental impacts (Fan *et al.* 2015). Some negative impacts of tourism include erosion of local culture and social harmony, problem of solid waste, water pollution and forest degradation.

Unlike Khumjung, where tourism was high, labour migration was high in Kalinchok and Majhigaun. More than 25% of surveyed HHs in Kalinchok had at least one family member working overseas (other than India). The overseas labour migration is not only a phenomenon in Kalinchok but it is widespread throughout the country and remittance has become one of the important pillars of the nation’s economy (*Economic Survey* 2014). The rising economy and booming construction in Gulf countries, Malaysia and South Korea and political change in Nepal in 1990 accelerated overseas labour migration. The labour migration has affected transhumance systems affecting labour dynamics and increasing HHs income. First, labour migration has created labour shortage for traditional farming systems. This has reduced the number of families practicing transhumance and reduced the number of livestock in the system resulting in lower mean LU in migrants HHs than in non-migrants HHs.

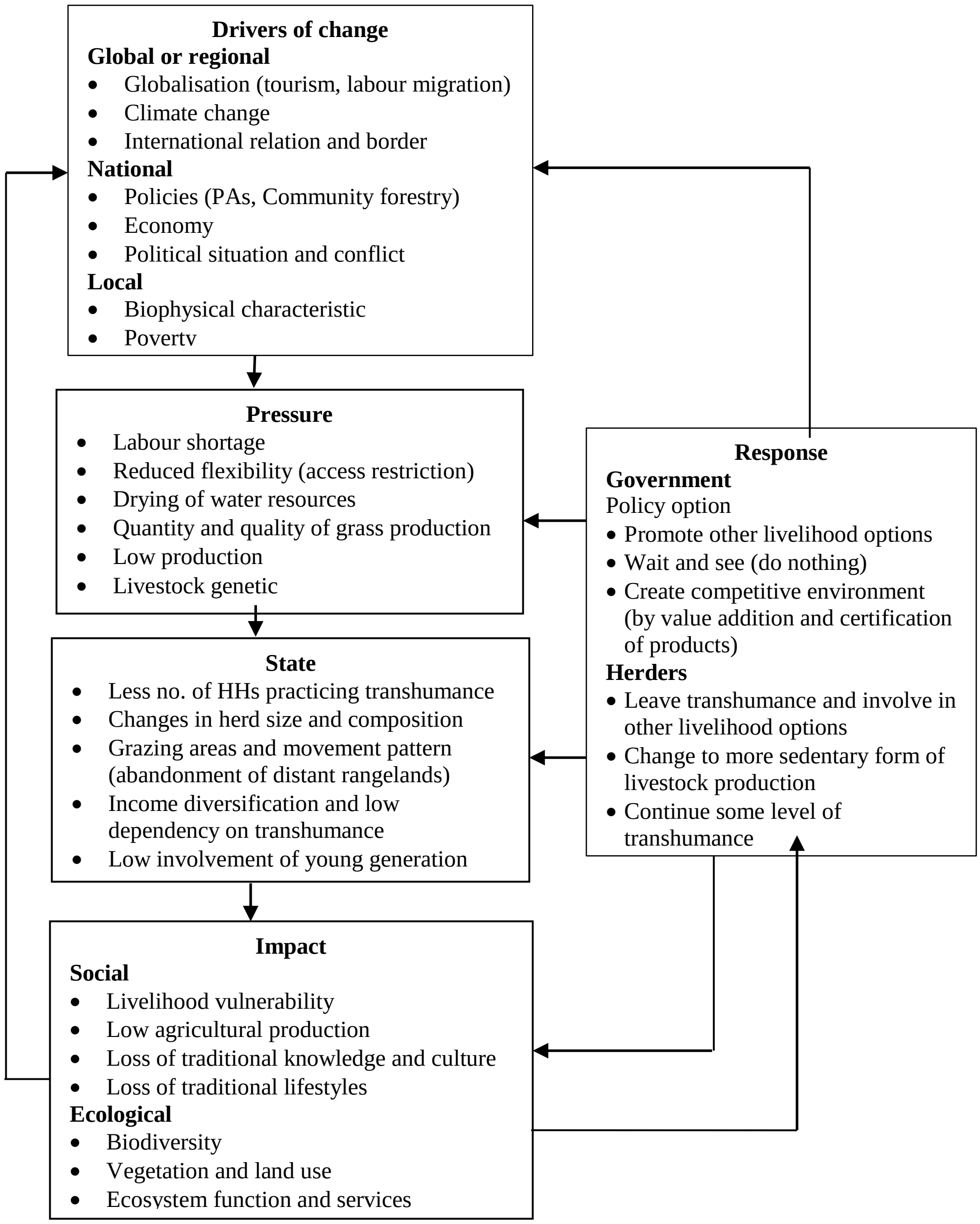

Figure 7-2: Driver-Pressure-State-Impact-Response (DPSIR) framework for transhumance systems

Many migrant HHs without livestock or with few livestock compared to non-migrant HHs was reported in mid-Hill of Nepal (Maharjan *et al.* 2012a). Second, labour migration has increased family incomes from remittance and reduced dependency on traditional systems. Previous studies (Khanal *et al.* 2015; Maharjan *et al.* 2012c) have reported that the labour migration has increased families' income, changed the lifestyles of family members and reduced involvement in farming in Nepal. Sometimes the receipt of remittance can promote farming practices and countervail the effect of labour shortage if they invest money in agriculture and livestock and in hiring labour

(Gray 2009). However, it was not the case in study areas. Though labour migration has played positive roles in HH's and the nation's economy, the detachment of rural people from traditional production systems might affect food production and food security in the long run (Gartaula *et al.* 2012).

Unlike Kalinchok where labour migration was to countries other than India, more than 50% of surveyed HHs mentioned that at least one family member in Majhigaun seasonally goes to Indian cities to earn cash. Although the LU was slightly higher in non-migrant's HHs than in migrant's HH, the difference was not significant as in the case of Kalinchok. The seasonal movement of people to Indian cities form Far-Western Nepal is a historical phenomenon (Thieme *et al.* 2003), however, a decade long political conflict accelerated the seasonal migration and abandonment of transhumance systems.

In addition to tourism and labour migration, education has also played a role in changing the transhumance systems. Schools were established even in the rural and mountainous regions of Nepal after the implementation of the National Education System Plan (NESP) in 1971. Governmental and non-governmental organisations had run, and are still running, many campaigns and awareness raising activities to enrol children in the schools after 1980 (MoE 2015). This has changed the attitude of people and they started to send their children to school. In the past, people were involved in some aspects of transhumance before teens. The increase in school enrolment changed the labour dynamics in the HHs and gradually decreased the involvement of young people in the traditional systems such as transhumance. While students complete school level education, they go to district headquarters or other cities which also affects the family labour dynamics.

From the above discussion, it can be concluded that the influence of globalisation has reached to the transhumant communities of the Himalayas such as through tourism, overseas labour migration, near migration (migration to India) and education. These processes were associated with the change in labour dynamics, household economy and preference of local communities towards different livelihood options and having the potential to affect different aspects of transhumance systems.

7.4.1.2 Climate change

This section broadly discusses how climate change can act as a driver of change to the TSESs. First, the trends of key climatic variables in the study areas are compared with the national and regional trends. Second, likely impacts of climate change on different components of transhumance systems (e.g. rangelands, livestock) are discussed. Finally, vulnerability of transhumant herders to climate change and factors affecting vulnerability are discussed.

Trends for key climatic variables, perceived changes in biophysical indicators and impacts to the transhumance systems

The pattern change for temperature in the study areas were in line with the pattern change for temperature for Nepal (NAPA 2010; Shrestha *et al.* 1999) and for the Himalayan region (Shrestha *et al.* 2012). The observed increasing trends were higher for the winter season than for the summer season which were also compatible with the findings of previous studies (Shrestha & Aryal 2011; Shrestha *et al.* 1999). There was no uniform pattern of rainfall across study sites (decreasing for Khumjung/SNP and Kalinchok/GCA, and increasing for Majhigaun/KNP). In Nepal, various patterns for rainfall have been reported (NAPA 2010; Shrestha *et al.* 2000). Previous studies (Bhutiyani *et al.* 2010; Shrestha *et al.* 2000; Xu *et al.* 2009) have also reported that there is no distinct long term pattern for rainfall in the Himalayas.

Climate change has potential to affect all three components (rangeland, livestock and herder) of transhumance systems directly or indirectly. An Inter-Governmental Panel on Climate Change (IPCC) (2007) predicted that the nature of precipitation in the higher Himalayas will change whereby there will be increasing rainfall instead of snowfall. The majority of the herders in all sites also agreed that the total amount of snowfall has decreased and it melts faster in the rangelands (Table 6.5). With higher amount of snow, it would melt gradually and provide moisture for a longer duration than rainfall. Decreasing amount of snowfall in combination with increasing temperatures can increase the deficit of soil moisture. This can affect the quality and quantity of grasses in the rangelands. The impacts of climate change to the rangelands could be more complex as it has the potential to alter the competition between plants, growth habits, productivity and plant-animal interactions (IPCC 2014) and decrease rangeland quality (Klein *et al.* 2007). Decreasing rainfall can lead to the drying of water resources (springs, rivers) and reduced water availability in the rangelands. In two sites (Khumjung and Kalinchok), where rainfall showed a decreasing trend, the majority of herders agreed that the water resources were dried up. Some literatures (Biggs *et al.* 2013; Chaudhary & Bawa 2011; McDowell *et al.* 2013) have also indicated that there was drying of water resources and an increase in droughts in Eastern part of Nepal. The drying of water resources can lead to the abandonment of rangelands which can add grazing pressure in other rangelands.

Furthermore, it has been reported that the growing season can advance and there can be changes in the phenology of plants in the Himalayas (Chaudhary & Bawa 2011; Lama & Devkota 2009; Shrestha *et al.* 2012; Xu *et al.* 2009). Regardless of sites, the majority of the transhumant herders agreed with statements that there is an early onset of summer season, early growth in greenery and early flowering/maturing of grasses. These changes can alter the timing of grass production, and the quantity and quality of grasses in the rangelands. The early maturity of the grasses in the rangelands can extend the duration for grass shortage because this time is followed by the winter season. Transhumant herders might have to make decisions in an environment of greater uncertainty. If herders respond to the early onset of summer and greenery moving upslope earlier, this can affect other agricultural activities such as planting and harvesting crops and ultimately disturb their seasonal calendar. Such changes in the calendars of local people might also have implications for the ecosystem and ecosystem management (Franco 2015). The increased temperature and longer growing season can increase the upper limit of grasslands and grass production. At the same time, the increase in temperature and changing precipitation can increase the encroachment of shrubs and trees in the grasslands (Naito & Cairns 2011; Zomer *et al.* 2014).

The appearance of new species in the alpine rangelands or an increase in the abundance of some species can be related to different factors. The majority of herders agreed that new species of plants were appearing (or have appeared) in the rangelands. Some species that were located at an adjacent lower elevation might have moved upslope due to an increase in temperature and associated range shift (Gaire *et al.* 2014; Klanderud & Birks 2003) or some shrub species might have encroached alpine rangelands due to an increase in drought, cessation of fire and range abandonment (Brandt *et al.* 2013; Sharma *et al.* 2013). Furthermore, some ruderal species such as *Iris goniocarpa* and *Euphorbia stracheyi* might have benefited due to increased nitrogen in highly grazed patches (Aryal 2010; Bauer 1990).

It is reported that livestock may be more susceptible to diseases due to increasing temperature. A large percentage of herders from Kalinchok and Majhigaun agreed with the statement that new livestock diseases were appearing. Although, it is yet to be investigated in detail, the increasing incidences of tick and blackflies as reported by herders from Kalinchok and Majhigaun might be related to climate change because the population dynamics and distribution ranges of many arthropod vectors are mainly determined by climatic variables (Gage *et al.* 2008; Stern 2006). A low percentage of herders agreeing to this statement in Khumjung might be related to two reasons. First, the study area inside Khumjung where vectors such as tick and blackflies were not reported is located in a high altitude and is cooler than in the other two sites. Second, the Yak Farm established by the Government of Nepal at Namche of SNP was providing basic veterinary services in the area. This might have reduced the perceived risk and damage from livestock diseases in Khumjung compared to Kalinchok and Majhigaun, since perceived risks and damages also affect perception (Ding *et al.* 2011; Weber 2010). However, many remote mountainous areas of Nepal where transhumance systems exist lack basic veterinary services. Therefore, the livestock production through transhumance could suffer more from the introduction of new diseases.

Vulnerability of transhumant herders to climate change and factors affecting vulnerability

The vulnerability analysis combined socio-economic and bio-physical attributes using multiple disciplines as needed to obtain a broader perspective (Adger 2006; McLaughlin & Dietz 2008; O'Brien *et al.* 2009). The variation in both the livelihood vulnerability index (LVI) and Climate vulnerability index (CVI) values across sites indicate that the vulnerability of transhumant communities across mountainous areas of Nepal varied, both overall and more dramatically in relation to the particular components and sub-components. The indexed values for the underlying components and sub-components (indicators) help to identify major contributing factors for the highest and lowest vulnerability in each site.

The 'health' and 'water' components were most influential in determining the outcome for the highest LVI for Majhigaun (Figure 6.10). The contribution from the 'health' component to increased livelihood vulnerability in this site is likely due to two reasons; people have to travel longer distance to reach the health and veterinary centre and they believe more in *dhami-jhakri* (traditional witch doctor). When herders or their livestock become sick, they first visit *dhami-jhakri* which further worsens the situation of the patients or sick livestock. This traditional belief in *dhami-jhakri's* efficacy has reduced the herders' flexibility (Holmelin & Aase 2013) which is required to reduce vulnerability. In the remote far-Western areas of Nepal, the level of awareness and education is low and traditional beliefs are deeply rooted compared to Central and Eastern Nepal (Wasti *et al.* 2011). Such social barriers and cultural dimensions affect vulnerability and adaptive capacity of the communities and are also important to determine how societies respond to climate change (Adger *et al.* 2013; Ford *et al.* 2006; Jones 2010). The component 'water' had an even larger influence on vulnerability in Majhigaun. There were no private or community-level water supply systems in Majhigaun and herders depend on natural sources of water such as rivers, springs and ponds with poor quality and inconsistent supply of water. In contrast, there were community-level drinking water supplies (taps) in two other sites which provide water consistently throughout the year.

In Khumjung, the 'food' and 'natural disasters' components largely contributed to LVI. The grain production in Khumjung is limited to very few crops (barley, wheat and buckwheat) because of the higher elevation (cold climate) and poor soil. Limited local agricultural production lasts only for a very few months to feed the local population. The contribution to local food from animal production such as dairy products has decreased compared to the past. This is because herders prefer to rear male livestock such as yaks and *jokpyos* (male hybrid of yaks/naks and cows/bulls and vice versa) than *chauri* as they can be used to carry baggage of the visitors and earn cash (Padoa-Schioppa & Baietto 2008). In contrast, crop diversity and production were high in Kalinchok and Majhigaun leading these villages to be food sufficient for a longer period of time in a year which helped to reduce vulnerability. Furthermore, the herders of Khumjung have experienced a large number of natural disasters, such as landslides, avalanches and drought, resulting in deaths and casualties of people and livestock. In Khumjung, lossof livestock due to avalanches was very common.

The increase in the number of income sources in the family should decrease vulnerability (Barrett *et al.* 2001). The average numbers of family income sources were less in Kalinchok increasing the index value for the ‘livelihood diversification’ sub-component. There were a large numbers of families solely depending on agriculture and livestock for HHs income. This contributed to the higher indexed value for ‘livelihood strategies’ in Kalinchok. In Khumjung, tourism and tourism related business has increased additional income opportunities, whereas in Majhigaun seasonal migration of youth to Indian cities and their earning (in terms of remittance) has diversified family income sources and has reduced the indexed value for this component. This suggests that the transhumant herders getting additional income and livelihood options such as by involving family members in tourism are likely to be less vulnerable.

There was little variation in the remaining components such as the ‘socio-demographic variable’, ‘social networks’ and ‘climatic variability’ and hence they contributed to a more or less similar extent in determining LVI. Geographical variables associated with mountainous areas such as inaccessibility, marginality and fragility (Jodha 1998) prevail in all sites and have similar social and physical setting. The results for the indicators under ‘social networks’ suggest that the transhumant herders help each other and have solidarity, which are useful in reducing vulnerability. The local institutions such as electing *nawa* in Khumjung and a *chauri* herder committee in Kalinchok can play important roles for local adaptations to climate change (Agrawal 2001).

Climate change vulnerability (CVI) has three dimensions i.e. the adaptive capacity, the sensitivity and the exposure. CVI of Khumjung and Majhigaun were higher than that of Kalinchok suggesting that transhumant herders of Kalinchok were less vulnerable to climate change compared to two other sites. More prominently, there was a variation in the level of exposure, sensitivity and adaptive capacity of the transhumant herders across study sites. Each dimension had the highest value for one site; the exposure in Khumjung, the sensitivity in Majhigaun and the adaptive capacity in Kalinchok (Figure 6.11). The differences in the dimensions and overall CVI across sites indicate that the spatial variation of climate change vulnerability in transhumant communities of the Himalayas. Moreover, it supports the idea that climate change vulnerability does not exist in isolation from wider socio-economic and bio-physical factors. The determinants of these dimensions and components vary significantly from system to system, sector to sector and region to region (Goldman & Riosmena 2013). They can be uneven within and across communities and are also scale-dependent.

The lowest sensitivity value and low exposure value in Kalinchok contributed to the lowest overall CVI. The indicators of ‘food’ and ‘health’ were comparatively better compared to two other sites. Indicators of ‘water’ were also far better than Majhigaun. Furthermore, transhumant herders of Kalinchok had low exposure compared to Khumjung because they experienced fewer natural disasters. Though Khumjung and Majhigaun had almost the same level of adaptive capacity, Khumjung had the highest CVI because of the highest exposure which is mostly due to frequent occurrences of natural disasters such as avalanches and landslides killing or injuring herders and livestock. Kalinchok had the relatively highest adaptive capacity; however, the diversification of herders' family income sources and reducing percentage of herder's family solely depending on livestock and agriculture could further enhance adaptive capacity. Improvement of health and water facilities and reduction of death and injuries from natural disasters can help to reduce the vulnerability of transhumant herders in Majhigaun and Khumjung respectively.

The global climate change has adversely affected many sectors in different ways (Bellard *et al.* 2012; Lejeusne *et al.* 2010; Mearns & Norton 2010; Wagener *et al.* 2010). Indigenous people are the least responsible for, but most threatened by climate change (Williams & Hardison 2013). The indigenous communities of the mountain have little access to alternative means of production and they could be more vulnerable than other communities (Nilsson 2008; Salick & Byg 2007; Salick *et al.* 2009). Though there are limited studies assessing the households and community level vulnerability to climate change in the Himalayas, Nepalese hill agriculture (Ghimire *et al.* 2010) and small scale irrigation system in Nepal (Cifdaloz *et al.* 2010) are at risk from environmental change. The climate change has added additional burden to the poor mountainous people living in the remote areas (Gentle & Maraseni 2012). This study showed that transhumant communities are vulnerable but for different reasons across sites.

The international community has focused on two major policies in response to climate change; reducing emission of greenhouse gases (GHGs) to slow down rate of temperature change and increasing the ability of nations, sectors and communities to cope with climate change i.e. adaptation (Ford & Smit 2004). The identification of adaptation needs starts with an assessment of the vulnerability (Ford & Smit 2004; O'Brien *et al.* 2009; Smit & Wandel 2006). The assessments of individual dimensions (exposure, sensitivity and adaptive capacity) of climate change for such rural communities is to provide insight to identify dimensions that required interventions to reduce the overall CVI.

The method used in this study can be applied to calculating and comparing vulnerabilities of other rural communities because the proposed method is flexible and indicators or sub-components can be changed or replaced while calculating vulnerability of a sector, region or communities. The assessments relate to several features of the communities including socio-demographic profile, livelihood strategies, social networks, assess to food, water and health and conditions of natural disasters and climatic variability as perceived by the communities. Hence, it provides the customised approach to the vulnerability assessment and the means to achieve the intended objective of identifying linkage of climate change impacts and social adjustments. This type of interdisciplinary work is critically important in order to focus on the solution phase of climate change impacts (Rosenzweig & Wilbanks 2010).

The integration of social science with global change science might transform global change research into action (Weaver *et al.* 2014). Since the suggested approach is based on long term realisations by the communities, the suggested coping strategies following such assessments could be best suited to local conditions. Furthermore, these indexes do not suffer from the limitations of secondary data-driven methods and missing data problems and has proposed to collect household level primary data for the purpose. In addition, the index values for sub-components would be useful in assessing the impact of a programme or policy by substituting the value of indicators (sub-components) that is expected to change and recalculating the overall vulnerability. Similarly, future vulnerability under some policy or programme intervention could be calculated to see whether the planned activities can reduce the vulnerability.

7.4.1.3 Regional tension and closure of border

Regional tension and the closure of the border (between Nepal and China) were not relevant in two study sites (Kalinchok and Majhigaun) as international borders do not lie in those areas and herders have not crossed the border even in the past. However, political change in Tibet and the closing of the border affected movement of livestock across borders, and marketability of livestock and livestock products in Khumjung. In the past, there was no restriction on herders going across borders to graze livestock and sell livestock products such as wool, butter and ghee or barter them with clothes, grains and salt. Nepalese herders from high altitude were using rangelands across the border for centuries (Bauer 1990). The demand for *jokpyo* was high in Tibet for ploughing fields and herders from Khumbu would supply large numbers of *jokpyo*. The governments of Nepal and China agreed in 1959 to close the border with Tibet by 1988 (McVeigh 2004). The reasons for sealing the border were the Sino-India war and incursion of Chinese into Tibet. The sealing of the border curtailed cross-border activities of herders in the Khumjung (Bauer 2000).

As in Khumjung, the effects from border sealing on Himalayan transhumance and trade have been reported by many scholars in Indian Himalayas (Bhasin 2011; Negi 2007) and Nepalese Himalayas (Bauer 2004; Gurung 208). Beside affecting trade across borders, there was an increase in livestock pressure leading to rangelands degradation in some areas (Oli 2008) and increased inbreeding in livestock due to reduced gene flow between livestock population in other areas (McVeigh 2004). In Eastern Nepal, some rangelands are getting intense pressure after the establishment of Singhalila National Park in Darjeeling (India) which restricted grazing and the Indian herders started to bring their yaks to rangelands of Nepal due to the open border (Oli 2008).

7.4.2 National level drivers

7.4.2.1. State conservation policies and practices

State conservation policies and local practices were also studied as drivers of change in the transhumance systems. The government of Nepal has executed different schemes of conservation and among them three schemes of conservation namely; Community Forest (CF), Conservation Area (CA) and National Park (NP) were relevant in the study areas. They differ in terms of access restriction to resource use and participation of local people in the management. On the one hand, conservation policies and practices were not supportive of transhumance grazing and on the other hand perceptions and attitude of herders were generally not positive. Expectations for transhumance was high and participation was low.

<u>Conservation policies and practices towards transhumance systems</u>

The review of conservation policies and practices showed that they have reduced the operational freedom and flexibility of transhumant herders. The state policies were either restrictive or flexible policies that could accommodate transhumant herders but were not implemented at local level. The provisions to form users groups based on traditional use of resources rather than following the political boundaries and to classify users into primary, secondary and tertiary based on use and need of resource (*Community Forestry Guidelines* 2008) indicate that the central level CF policies were flexible and could provide space to accommodate transhumant herders. However, they were not necessarily applied at local level. The heterogeneity (considerable variation in necessities and dependencies over CF) among members can make it difficult to achieve consensuses for a common goal (Chand *et al.* 2015). This has increased the chance for conflicts and for domination by local elites.

Previous scholars (Malla *et al.* 2003; Uprety *et al.* 2012) reported that elite control occurs in CF of Nepal at local level which has affected the livelihood of poor and needy people. Community Forest Users Groups (CFUGs) were either completely restricting grazing or were allowing grazing for certain periods of time for the members of CFUGs. Transhumant herders suffered from restriction of grazing and fodder collection and they were blamed for forest destruction by CFUGs. The herders who were not members were not allowed grazing or were charged fees for grazing. Furthermore, the provision in the policy that CFUGs can sell forest resources and generate income for community development programmes led to CFUGs starting to raise fees from livestock grazing. The transhumant herders expressed feeling of exclusion from the process of forming CFUGs and operational plans.

The concept of CA was introduced in Nepal with the philosophy of community based conservation (Heinen & Mehta 1999; Keiter 1995). However, the provision to form Conservation Area Management Committee (CAMC) following Village Development Committee (VDC) boundaries as given in the *Conservation Area Management Rule* (1996) does not match with the traditional resource use practices. Herders from other

VDCs are automatically excluded where transhumant herders might have to graze across the VDC boundary. This has the potential to initiate conflict among resource users as seen in the upper Mustang within the Annapurna Conservation Area (Aryal *et al.* 2013). Again there is a chance of the domination by local elites as there is heterogeneity among local people living in the VDC. Kellert *et al.* (2000) also indicated that the devolution in CAs in Nepal has concentrated power to certain groups of people.

NP policies and laws of Nepal represent 'fortress and fine' model. These policies initially focused on wilderness conservation and protection of charismatic wildlife where traditional resource use and customary practices were curtailed. The introduction of *Mountain National Park Regulation* (1979) allowed people inhabiting mountainous parks subsistence use of resources such as fuelwood and fodder, and grazing livestock in the designated areas and times. For KNP, where there were no inhabitants in the park, a separate *Khaptad National Park Regulation* (1987) was formed to allow people residing in peripheral areas of the park to graze livestock in the rangelands inside parks after paying fees and getting written approval from the park. Although the provisions in these regulations were more flexible than in the original act, and herders get some opportunities for grazing for designated time periods after paying fees, the operational freedom required for traditional systems has been reduced by the implementation of NP rules and activities. The access restrictions can also compromise the flexibility of the herders (Chakravarty-Kaul 2013; Dong *et al.* 2010).

The analysis concludes that the operational freedom and flexibility of herders are curtailed by the implementation of CF and protected areas (PAs) (CA and NP). In the case of the CF, polices that could accommodate different users such as transhumant herders were not implemented at local level. The policies to form CAMCs following the political boundary of VDC has the potential to exclude herders from other VDCs in CA. The grazing in designated areas and time inside NP with or without paying fees is not in line with the seasonal movement of livestock in transhumance systems. These provisions and practices can disrupt traditional grazing patterns and seasonal calendars of herders.

<u>Perception and attitudes of transhumant herders towards CF, CA and NP</u>

Transhumant herders showed low positive perceptions and attitudes towards CF, CA and NP. These results are similar to those of Mehta and Kellert (1998) and Heinen (1993) who reported low levels of positive attitudes of local people towards PAs of Nepal. However, these findings contrast with Karanth and Nepal (2012) who reported that the majority of the residents held positive attitudes towards the existence and importance of PAs. Studies from other parts of the world also revealed that local people can have positive (Badola *et al.* 2012; Guerbois *et al.* 2013; Sekhar 2003) and negative (Fialloa & Jacobsona 1995; Nautiyal & Nidamanuri 2012; Wang *et al.* 2006) attitude towards conservation measures and a myriad of factors are relevant to shape these attitudes.

Perceptions and attitudes towards conservation are multi-faceted (Larson & Lach 2008). In general, livelihood concerns such as dependency toward natural resources (Allendorf 2007; Arjunan *et al.* 2006; Xu *et al.* 2006) and perceived benefits (Allendorf *et al.* 2006; Sekhar 2003) influence the attitude of people towards forest management and conservation. One of the important reasons for having less positive perceptions and attitudes could be the high dependency on forest and rangeland resources of transhumant herders. They had to depend on these areas to graze livestock and get fodder and fuel wood. The conservation measures were implemented in the areas where they were practicing transhumance and the mobility and flexibility which are the ecological requirement of transhumant pastoralists (Gooch 2009) are curtailed by the implementation of CF, CA and NP (as given in section 6.3).

Although the percentage of responses agreeing with statements under positive perception and attitude were less than 25% for all schemes of conservation, the responses agreeing with negative perception and attitude were much higher in NP indicating that the overall perception and attitude was less favourable in NP than in CF. To some extent this might be related to the scheme of management/conservation. Previous studies (Fialloa & Jacobsona 1995; Xu *et al.* 2006) have also claimed that the flexible management model increases positive perceptions and attitudes. Community based approach such as CF have been perceived to generate more positive attitude toward conservation than state-led (Lepp & Holland 2006). There is a widespread advocacy and publicity throughout the country that CF is a good example for the forest management and rural development in Nepal, and as a successful model of participatory resource management globally (Ahlborg & Nightingale 2012) which might have reduced negative attitudes and perceptions toward CF.

In contrast to CFs, NPs are based on top-down approach and are a ‘fortress and fine’ model. Implementations of such models can break down the local community-nature relationships particularly in developing countries (Nautiyal & Nidamanuri 2012). In Nepal, NPs have often been established in the customary territories of indigenous peoples with no regard to the socio-economic situation (Seeland 2000; Stevens 2013). Although there were some provisions for livestock grazing in specified areas for the park inhabitants in SNP and for herders from surrounding settlements in KNP in designated time and areas after paying fees, free movements and operational freedom were curtailed in NP. Herders were often blamed for illegal activities such as poaching and were arrested and frequently threatened by park staff. In conservation schemes with strict regulations, actions of local people might be influenced by memory, fear, threats or expectations of violence (Norgrove & Hulme 2006).

Expectations of transhumant herders towards CF, CA and NP

More than 65% of responses agreed with statements under expectations in all schemes of conservation (Figure 6.7a). The uses of resources from the forests and PAs are of great importance to the livelihoods of local people in Nepal (Stræde & Treue 2006). The dependency on natural resources and their use are influenced by the socio-economic condition/factors (Badola *et al.* 2012; Tomićević *et al.* 2010). Rural poverty further increases the need for access to natural resources in forests and PAs (Fialloa & Jacobsona 1995). Transhumant herders were traditionally grazing their livestock in the CF and PAs in the study sites. The use of trails through CF and PAs, collection of grasses and fodder, firewood and constructing *goths* were other essential activities. Therefore, it was usual for transhumant herders to agree with statements under expectation.

Participations of transhumant herders towards CF, CA and NP

The proportion of responses agreeing (strongly agree + agree) with statements under participation were low (about 25%, 50% and 22% for CF, CA and NP respectively). According to Siebert *et al.* (2006), participation of local people towards conservation is affected by their willingness, ability, wider social influences, policy design, content and local practices. People or families do not have equal potential to participate. Socio-cultural, financial and political barriers can also hamper the participation (Minter *et al.* 2014). Even if a significant number of seats are reserved on the management board, there can be ‘manipulative participation’ (Pretty 1995) and a meaningful participation (Clarke 2008) or self-mobilisation is affected by social barriers. A feeling of exclusion (related to local power structure) and other priority activities to be performed to fulfil the daily requirements also lessens participation (Méndez-López *et al.* 2014). In a heterogeneous community such as in the study areas, the need for resource use, access to information, daily activities and time availability, perceived and expected benefits and day to day requirements vary within the community people. The possible reasons for low participation of transhumant herders in each scheme are discussed below.

Though community forestry in Nepal is considered successful in improving forest conditions and peoples livelihood in a number of ways (Pokharel & Nurse 2004), it is also criticised for impacting traditional livelihoods of poor and marginalized communities (Lachapelle *et al.* 2004; Uprety *et al.* 2012). There are literatures (Dasgupta & Beard 2007; Platteau 2004) indicating ‘elite capture’ as a major problem of community driven development programmes initiated by governments or development projects funded by aid agencies preventing benefits from reaching target groups. Thoms (2008) and Pokharel and Nurse (2004) indicated the existence of elite capture in CF of Nepal where poor households are bearing the costs of strict rules. The mismatch in the CF of Nepal whereby people having every day and hereditary experience of forests are disregarded as illiterate and ignorant, while people who do not work in forests claim to be knowledgeable (Ahlborg & Nightingale 2012). Such skewed access to natural resources where local elites benefit widens gaps and fertilises conflict among local people (Dressler *et al.* 2013). Transhumant herders are in a minority as compared to the rest of the local people. There were some reports where transhumant herders are blamed for forest degradation, harassed by CFUGs and eventually they ceased participating (Banjade & Paudel 2008).

Transhumant herders who were using forests for grazing for generations might have expectations to continue grazing whereas other users might oppose grazing in CF initiating conflict among local users. This might have developed a sense of opposition among transhumant herders with other locals (generally members of CF) who are generally neighbours from the same village. This showed that the implementation of CF affected the trust and expectations between community members termed as social capital (Robbins 2012). The adverse effect of CF on poor people was also highlighted by other studies (Lachapelle *et al.* 2004; Malla *et al.* 2003) and there is an explanation that 'egoistic value' (van Riper & Kyle 2014) might have such negative influence.

Comparatively higher level of participation in CA than in CF and NP might be due to herders participating with the hope that they can raise their issues and establish provision for transhumant herding inside GCA. GCA was just established when the field study was conducted and the management responsibility was handed over to National Trust for Nature Conservation (NTNC) for 20 years. However, there is a chance of conflicts as CAMCs are formed at VDC level that might not be in line with the traditional use, mobility and flexibility of transhumant herders. Such conflict was reported from upper Mustang which was under Annapurna Conservation Area Project (Aryal *et al.* 2013). There is also a chance of elite control and unequal distribution of benefits in the CAMC as reported in other CAs (Dahal *et al.* 2014; Kellert *et al.* 2000) and CFs (Thoms 2008) of Nepal. GCA, being in the initial stage of development has an opportunity to deal with these issues from an early stage.

One reason for the low level of participation in NP is a lack of legal and policy provisions. There were no clear mechanisms to involve local people in park management. Stevens (2008) also reported the lack of provision to involve local people in NPs of Nepal. Another reason for the low level of participation could be that herders are not hopeful that their participation can change the way that NP treats local herders, respect transhumance grazing and create provision for free grazing. Participation is related to the perceived benefits (Sekhar 2003) but customary rights are dismantled by the implementation of NP. Conservation and development intervention undertaken by the Government of Nepal (GoN) has affected resource use pattern in the High Himalayas (Bauer 2004). The protected area management plans are often developed without taking into account the needs of herders and their livestock and ignore local traditions and customs (Dong *et al.* 2010).

Generally, there were no satisfactory relationships between different schemes of conservation and transhumance systems in Nepal. On the one hand, conservation policies and practices have reduced the operational freedom and flexibility of transhumant herders. On the other hand, the perception and attitude of transhumant herders (who are also the key components of dynamic social-ecological systems) towards conservation were low, expectations were high and participations were low. Such relationships could be counter-productive for both the conservation and transhumance systems. Even though the CF policies were more flexible than CA and NP, the policies were not necessarily implemented at a practical level, and perceptions and attitudes slightly differed across different schemes of conservation. The low level of positive attitude and high level of negative attitude of transhumant herders whose subsistence livelihood depend on the direct utilisation of resources indicate that there is a need for improvement in policies and practices.

7.4.2.2. Political instability and conflict

One reason for the decline in number of HHs practicing transhumance in Kalinchok and Majhigaun was a decade (1996-2006) long political conflict between Maoist cadres and the State's military in Nepal. Insurgents tried to take strategic advantages from mountain terrains using them as refuge (UNEP-WCMC 2002). Herders mentioned that they suffered from both State's Military as well as Maoist's cadres. They were often suspected as spies of the opponents side and there was no secure environment to move with livestock and stay in the jungle and rangelands. There were similar cases in Phillippines where armed conflict between States armed forces and the armed wing of the Communist Party (the New peoples' Army) victimised Agta (Minter *et al.* 2014) and Ifugao (Kwiatkowski 2013) communities. The political conflict also accelerated overseas labour migration from Kalinchok and seasonal migration to Indian cities from Majhigaun though the seasonal migration to the Indian cities from far-Western Nepal was a historical phenomenon. This suggests that the conflict accelerated systematic change. Now the political conflict is over and the country is in a new political regime, however, it is uncertain whether or not the traditional system will recover. Although the number of livestock increased with the stabilisation of the conflict, the number of goats increased at a faster rate than other livestock types in Majhigaun suggesting that there could be changes in different aspects of transhumance systems even if they recover. Sometimes the change could be irreversible because the systematic change in traditional systems could be associated with the socio-economic and cultural transformation of the communities (Marini *et al.* 2011).

7.4.3. Local level drivers

Biophysical characteristic includes climate, terrain and topography, soil quality and types, water availability, rangelands conditions, their distribution and productivity. The higher Himalayas in general are more fragile, inaccessible, marginal and diverse (Jodha 1998). The terrain is rugged with steep slopes and soil is poorly developed. The rangelands are less productive and the grazing resources are scattered over larger spatial areas across different ecological zones along the elevation gradient. Due to these features, the physical hardships are greater in the higher Himalayas and socio-economic processes are shaped by those features (Banskota 2000; Jodha 2005a). As transhumance based livelihood options need to deal with such bio-physical characteristics, people of young generation generally see this option more difficult and when an alternate livelihood option is available, they prefer to switch from transhumance systems.

Poverty is also one underlying factor leading to changes in the transhumance system. The Himalayas is a home for growing numbers of rural poor whose livelihood is based on direct utilisation of natural resoruces (Sandhu & Sandhu 2015). Nepal is a least developed country and poverty is widespread. Poverty is even more deeply rooted in the remote mountainous areas (Pyakuryal *et al.* 2010). Poor people are likely to have larger families, lack investment capital and face insecure property rights (Hazell & Wood 2008). The people practising transhumance in the Himalayas own limited land. The food produced in their land can feed their family for only a few months of a year. The potential impacts from different factors to resource-poor people can be considerable (Thornton & Herrero 2008). When an alternate income source is available, poor people who are seeking other income options tend to switch their profession readily. Overseas labour migration from Kalinchok and seasonal migration to Indian cities from Majhigaun were related to poverty and economic reasons.

The discussion showed that the drivers of changes at different scales (global, national and local) were creating pressure to the transhumance systems directly or indirectly. The next section discusses the major changes in the transhumance systems.

7.5. Major changes in the transhumance systems

Although there were no or limited data available to study the changes in the transhumance systems over time, available data and perceptions of herders indicated that there were changes in different aspects of transhumance systems owing to pressures from different drivers of change. In all sites, herders perceived that the number of families practicing transhumance has declined which is also supported by the declining trend of total number of *goths* inside KNP. Other perceived changes were decreased herd size, changes in grazing areas and herding patterns, reduced dependency on transhumance systems and low involvement of young people, though the changes were not uniform across sites. Those changes generally indicate that the transhumance systems were declining in the study areas. Similar to the perceived changes in the transhumance systems by the herders, traditional farming systems have been disappearing, declining or transforming globally. Some examples of traditional farming systems undergoing rapid transformation include swidden cultivation (shifting cultivation or slash and burn system) (van Vliet *et al.* 2012) and different types of pastoralism (Dong *et al.* 2011).

As observed in the study areas, studies from different parts of the world reported changes in different aspects of pastoral systems. Most of the studies suggest that the pastoral systems are declining. The low number of families involved in pastoralism in

Yunan, China (Shaoliang *et al.* 2008) and Kumaon, Inida (Negi 2007), declining livestock population in Nanda Devi Biosphere Reserve in India (Nautiyal *et al.* 2003), small herd size in Ethiopia (Desta & Coppock 2004) and replacement of long distance movements with short distance movements in Romania (Huband *et al.* 2010; Juler 2014) and West Africa (Turner *et al.* 2014) indicate declining trends in pastoral systems. Similarly, the dependency of pastoral production has been reported to decrease in Africa (Ayantunde *et al.* 2011) and China (Shaoliang *et al.* 2008) and less involvement of young people (generations) in transhumance has been reported in Bhutan (Namgay *et al.* 2013; Wangchuk & Wangdi 2015). There are, however, few studies reporting that the number of livestock or number of families practicing pastoral production has increased. In the trans-Himalayan region of Ladakh (Jammu and Kasmir in Northern Inida), the areas under pastoralism has decreased but the livestock population has more than doubled between 1977 and 2006 (Singh *et al.* 2013).

The change in the historically practiced transhumance systems might have several social-ecological implications in the society and ecosystems, and the next section focuses on likely social-ecological consequences of the loss or decline of the transhumance systems in the Himalayas.

7.6. Social-ecological impacts from the change in the transhumance systems

Transhumance systems are coupled social-ecological systems (Figure 1.1). Both social and ecological systems co-evolved and persisted for centuries. In such SESs, both systems are tightly connected and often mutually reinforced (Li & Li 2012). Therefore, the changes in the social systems of a SES affect ecological systems and vice versa. The presences of change pressures on either sphere of SES add feedback loops in the systems and can lead to the structural transformation of the entire system. The decoupling of the social or ecological systems can induce far reaching social-ecological impact. Here some of the impacts that are likely from the changes in the transhumance systems in the higher Himalayas are described.

7.6.1. Social impacts

Based on the socio-economic and cultural significances of the transhumance systems (presented in chapter 4), likely social impacts such as effect on livelihood, effect on crop production, and customary lifestyles, indigenous knowledge and culture (Figure 7.2) from the loss or decline of transhumance systems are discussed.

7.6.1.1.Effect on livelihood

Transhumance is being practiced in the Himalayas since the early human civilization and is one of the important livelihood activities. The loss or decline of transhumance systems affect the livelihood of marginal people who are practicing transhumance. In the mountainous areas of Nepal where agricultural production is low and poverty is high (Pyakuryal *et al.* 2010), livestock production is an important livelihood option

(Maltsoglou & Taniguchi 2004). The proportion of houeholds (HHs) practicing transhumance (considering HHs owning some kind of livestock) ranges from 17.5% (in Majhigaun) to 40% (in Kalinchok) in the study areas and it is one of the most important livelihood activities contributing more than one fourth of total HH's income in all sites (Table 4.7). The degradation of rangelands for any reason, access restriction, drought and increase in pests and diseases can reduce livestock productivity, ultimately affecting the livelihood of people practicing transhumance. Furthermore, transhumance has provided livelihood option for people who lack formal education, technical skills and capital (money) who cannot switch into alternate livelihood options. Even if alternate livelihood options are available, all herders might not be able to switch to these options or cannot work elsewhere for family and other reasons. Sometimes, the shift to alternate livelihood options such as tourism or labour migration can increase household's income and improve living standard. However, the sustainability of those alternative options is an important issue to be considered. The sustainability of alternative income and livelihood options such as tourism and overseas labour migration can be affected by a number of factors such as natural disasters, political conflict, changes in tourist preferences, change in visa regulations and downturn in the economy of other countries etc. In such situations, transhumance and other taraditional production may be like a safety net and the break down from traditional livelihood options and adaptation strategies can make people and communities more vulnerable (Jodha 2005a).

7.6.1.2. Effect on agricultural (crop) production

As noted earlier (section 4.3.2 and 7.2.4), the integration of transhumance livestock production with crop production has derived mutual benefits and were inseparable to each other. This indicates that the loss or decline of the transhumance system is likely to affect crop production. The dependencies of crop production on livestock were high as livestock were the only source of manure and draught power. In the study areas there was not enough food production to feed local population, and in one site (i.e. Khumjung), it was enough just for three months. Livestock products supplement diet in those areas especially for those families who are involved in the transhumance. Therefore, the loss or decline of the transhumance system and decrease in crop production can further reduce food security and increase livelihood vulnerability.

7.6.1.3. Loss of customary lifestyles, traditional knowledge and culture

It is difficult to say whether the loss of traditional systems is positive or negative. The effects may vary in both spatial and temporal scale (Fan *et al.* 2013). Even if the transition from transhumance to alternate income sources offers immediate economic benefits, the loss of transhumance systems can be associated with social costs such as accelerating loss of customary lifestyles, traditional knowledge and ancestral culture. The loss of such knowledge and culture might be irreversible as they are linked to broader process of social transformation (Marini *et al.* 2011).

Due to the interactions with nature and transmission of knowledge and experiences for generations, transhumant herders have knowledge about local agro-ecological conditions, plants and animals. The knowledge and experiences were useful in herd and grazing management. The losses of transhumance systems mean loss of such traditional knowledge. This can also affect cultural landscapes such as rangelands of the higher Himalayas which are historically subjected to human use (Dong *et al.* 2007; McVeigh 2004). The loss of such knowledge primarily affects people who depend on the same land as in the past, but traditional methods, knowledge and social institutions no longer exist. Furthermore, transhumance itself was evolved as a culture of local people in the higher Himalayas (Namgay *et al.* 2013). As described in section 4.3.3, traditional songs, dance, folklore and language of local people in the study areas indicate strong association between culture and livestock or transhumance. Some livestock were also associated with religions and there were several norms, taboos and customary regulations related to livestock. These socio-cultural traditions are likely to disappear with the loss of transhumance systems.

7.6.2. Ecological impacts

The ecological impacts that are likely with the loss or decline of transhumance grazing in the Himalayan rangelands can be inferred from the findings on grazing impacts on plant species richness and composition. This is absolutely important because pastoral practices in general, and the summer livestock grazing in the Himalayan rangelands in particular, are constrained for different reasons. Studies from other regions such as in Alps (Tocco *et al.* 2013) and in the Tibetan Plateau (Urgenson *et al.* 2014) have shown adverse ecological consequences from the loss of traditional grazing practices. As transhumance systems were co-evolved with nature for centuries in the higher Himalayas, the decline or cessation of historic livelihood and land use practices can alter the disturbance regime. This change can affect biodiversity, land use, and ecosystem functions and services (Figure 7.2).

7.6.2.1.Biodiversity

The future impacts from the loss or change in transhumance systems on the biodiversity can be inferred based on its current roles. In relation to the existing debate (perceptions) about transhumance grazing and its effect on plant biodiversity in the Himalayan rangelands that I introduced in the initial chapter, this study found that adverse impacts were near *goths* and in other zones was associated with greater species richness. The occurrence of rare species at mid and further distance from *goth* (within 800m transects) suggest that transhumance grazing has not threatened rare species. Generally, high plant diversity is desirable because it buffers environmental fluctuations and enhances resilience of grasslands (Volaire *et al.* 2014). Conservation priority, however, concentrates on rare and endangered species. From both of these aspects, light grazing might be beneficial in the Himalayan rangelands but adverse impacts near *goths* would need to be avoided.

Furthermore, transhumance grazing might be advantageous for the conservation of endangered wildlife too. Previous studies from the Himalayan region (Shrestha, B. *et al.* 2012; Shrestha *et al.* 2005) suggest that snow-leopard (endangered and iconic species for conservation focus in the higher Himalayas) prey on both wild and domestic ungulates. Those studies also indicate that there is a diet overlap and competition between domestic livestock (such as sheep, goat and yak) and wild ungulates (blue sheep and Himalayan tahr) and usually suggest reducing the number of domestic livestock. However, Bauer (1990) reported that utilisation patterns between wild ungulates and livestock differs. Furthermore, the most neglected aspect is whether or not snow leopards get sufficient prey in the absence of domestic livestock as those studies (Shrestha, B. *et al.* 2012; Shrestha *et al.* 2005) suggest that snow leopard significantly preys on domestic livestock, which sometimes constitutes more than 58% of diet (Bagchi & Mishra 2006).

Historic land use practices such as grazing livestock increase the heterogeneity, proportion of early succession plant species, and availability of forage and browsing for wild ungulates and their predators (Siebert & Belsky 2014). However, there is no studies on how the absence of domestic livestock will directly affect food availability for snow leopard and its prey species (e.g. blue sheep, Himalayan tahr) and other wild herbivores (e.g. musk deer, Himalayan tahr) having conservation focus in the higher Himalayas. However, there are indications that the abandonment of grazing in Himalayan rangelands will proliferate shrub encroachment (Rai 2013; Sharma *et al.* 2013) which can change the grass availability for those herbivores. Furthermore, the Himalayan rangelands are of particular concern due to high endemism (Salick *et al.* 2009) and an increase in shrub cover can threaten such endemic biodiversity (Brandt *et al.* 2013). When shrub cover exceeds a certain level, it reduces plant diversity (Anthelme *et al.* 2003; Dullinger *et al.* 2003) and also alters breeding habitat and food resources of migratory birds (Boelman *et al.* 2015) as reported from other regions.

7.6.2.2. Vegetation and land use

Himalayan rangelands are cultural landscapes subjected to human use for centuries and the abandonment of traditional practices might alter the vegetation and land use. Predicting future vegetation and land-use dynamics in the absence of livestock in the Himalayan rangelands is one of the important scientific and management challenges. Very few herders from Khumjung/SNP and Kalinchok/GCA are reaching to the distant rangelands as compared to the past which indicates that the rangelands which are a long distance from settlements are likely to be abandoned and the effects of grazing abandonment are likely to appear in those rangelands. Some studies (Nautiyal & Kaechele 2007; Sharma *et al.* 2013) have indicated that the shrub and bush cover is likely to increase in the Himalayan rangelands after grazing abandonment which is also the case in other mountains (MacDonald *et al.* 2000; Poyatos *et al.* 2003).

As vegetation responds differently to different types of livestock; changes in livestock composition can also effect vegetation (Kerven *et al.* 2012). The change in dominant livestock from cattle to goat in Majhigaun/KNP before and after the civil war might draw attention to this aspect. Furthermore, the increase in temperature, change in rainfall patterns and drying of water resources due to climate change may compound with decline or change in herding patterns to affect vegetation dynamics and land use pattern (Sturm *et al.* 2001). If people who were using distant rangelands begin to graze livestock in the nearby communal lands (forests or rangelands) or private lands, it is likely that the grazing pressure in the nearby areas will increase. The distant rangelands which become abandoned as well as nearby rangeland that get more livestock pressure can be degraded in such a situation (Bruegger *et al.* 2014).

7.6.2.3. Ecosystem function and services

The decline or loss of transhumance systems might affect ecosystem function and services in the landscape. The scenario presented by Oteros-Rozas *et al.* (2013b) is useful to understand how different ecosystem services become affected by the collapse of transhumance systems. The changes in species diversity and vegetation composition as noted earlier could alter ecosystem functions (Archer 2010; Chapin *et al.* 2000). Grazing can affect the ratio of aboveground and belowground production in the rangelands, nitrogen uptake by plants and level of litter and nitrogen in the ground (Bagchi & Ritchie 2010). Grazing by large herbivores can influence carbon balance (Falk *et al.* 2015), and probably the mineralisation and bio-geo-chemical cycles etc. The increase in shrubs can increase the extent of fire in the rangelands which may affect endangered species. The mountains are considered as the water towers of the world and supply fresh water to half of the world's population (Messerli *et al.* 2004; UNEP-WCMC 2002). The rivers originating from the Hindu-Kush Himalayan (HKH) region supply water to over 20 % of the global population (Immerzeel *et al.* 2010; Xu *et al.* 2009). The change in vegetation can combine with climate change and alter the water flow in the streams originating or flowing from the areas, affecting people living in both the upstream and downstream areas.

The Himalayan rangelands also provide valuable ecosystem goods and services. Changes in vegetation in the high Himalayan rangelands may alter the provision of ecosystem goods (grass, food, medicinal plants and genetic resources) and aesthetic and spiritual values. For example, the increase in shrub cover due to grazing abandonment can reduce grass production in the rangelands which can again affect livestock production ultimately affecting livelihood of herders and contributing to changing pressures on the traditional system. The increasing tourism in the mountainous area of Nepal is one example of soaring consumption of aesthetic values of mountain landscapes which can be altered with the change in vegetation. The open rangelands such as in KNP are main attractions of KNP that have potential to attract tourists. However, if the grazing is abandoned and they are encroached by shrubs and forests, the scenic beauty of the landscape can change.

7.7. Local adaptation strategies

Mountain communities have historically tried to reduce bio-physical and socio-economic vulnerabilities by adjusting demands to restrictions imposed by mountain circumstances and adapting to mountain conditions (Banskota 2000; Jodha 2005d). Transhumance herding itself can be considered as a supply driven adaptation strategy in mountainous areas. The combination of agricultural practices near permanent settlements and livestock rearing away from the village is a flexible strategy for adaptation in high altitude areeas of the Himalayas (Bishop 1989). Most of the strategies practised by herders (Table 6.10) evolved historically in response to harsh climate and remote geographical areas and some of them were strategies in response to recent pressure of changes.

The mobility, storage and diversification (Table 6.10) contribute to better adaptation because these strategies spread risk across space, time, and assets respectively (Agrawal 2010; Fu *et al.* 2012; Wu *et al.* 2014). The strategies under collective action and social capital reduce vulnerability because they produce a synergistic effect to deal with hard situations (Adger 2003). Most of the traditional strategies practiced by local people were derived from the freedom and flexibility of herders in the past. However, the flexibilities in the pastoral groups have been eroded due to different factors including change in socio-economic conditions and policy decisions (McCarthy & Martello 2005; Tyler *et al.* 2007; Wang *et al.* 2014). Both non-climatic and climatic stressors have pushed some Andean pastoralists beyond their range of adaptability (López-i-Gelats *et al.* 2015). While traditional measures are weakened or broken and no new measures are introduced to deal with current changes, rural communities could be more vulnerable.

Some people can adapt to a changing context (Jurt *et al.* 2015) and some local communities of the Himalayas have also adjusted livelihood options to socio-economic and environmental change (Chaudhary *et al.* 2007). For example, the use of yaks and *jokpyos* in tourism business in Khumjung was to trap income from tourism which had helped to increase HHs income from livestock production. Overseas migration from Kalinchok and seasonal migration to Indian cities from Majhigaun were to take advantages of income opportunities and diversify income sources. They can also be described as self-adaptation strategies to changing conditions to improve their living conditions (Wu *et al.* 2014).

Sending herders in rotation and combining small herds of different households (HHs) and use of yaks or *jokpyos* to prepare (plough) agricultural fields might be strategies transhumant herders developed in response to labour shortage**.** Some herders were responding to change by changing livestock. In Khumjung, herders preferred to keep male yak and *jokpyo* as they are increasingly demanded as a means of transport. There were two reasons for the sharp rise in numbers of goats compared to other livestock types in KNP after heavy decline during political conflict. The first reason for this is small amounts of money to invest initially. And the second reason for this is they can sell goats when they need money easily in the village because some middle man comes to buy goats at their home, collects and takes them to district headquarters.

The families who had abandoned *chauri* rearing and herding large flocks of sheep and goat in Kalinchok have started to keep a few cattle and buffaloes as they could be reared in more sedentary form and grazing nearby settlements. Some herders in Khumjung have started to buy and store hay and grass in response to grass shortages in the winter season. They are the ones who have maintained or even increased herd size to use livestock in tourism. These strategies look like the strategies in the western mixed farming. In Kalinchok, some herders have planted improved grasses and fodder trees in private land in the edge of farmlands. The distribution of seeds and seedling and encouraging herders to plant in their private land can reduce pressure in the CF in one hand and on the other hand can reduce the severity of herders who are suffering from grazing restriction in CF.

Traditional strategies and knowledge of pastoral communities can be useful in mitigating effects from climate change and increasing the resilience of social-ecological systems (Nyong *et al.* 2007; Oteros-Rozas *et al.* 2013a; Turner & Clifton 2009; Yeh *et al.* 2013). The local adaptation strategies could be effective to lessen certain levels of shocks from climate change. When climatic variability exert a strong influence deviating many degrees from a "coping range", transhumance systems might be further affected (Nardone *et al.* 2010), traditional practices might be less significant for the viability of traditional systems and more proactive and systematically planned adaptation responses might be required (Ash *et al.* 2012). Therefore, the degree of changes that the current strategies of transhumant herders can withstand and what strategies need to be applied to higher degree of changes need further investigations. Furthermore, the adaptation to systematic threats such as climate change should not only be attributed to local (Nalau *et al.* 2015) and need more support from governmental, non-governmental and private sectors to enable them to move beyond those practices to long-term anticipatory strategies to enhance resilience to systematic threats such as future climate crisis.

7.8. Possible responses and future scenarios

As societies are changing and there are various accelerating change pressures, it cannot be expected that the dynamic social-ecological systems (SESs) remain as they were in the past or as they are in the present. Although there were some examples of self-adaptation such as by integrating transhumance with crop production (in all sites), changing livestock types (in Khumjung and Majhigaun) and use of livestock in tourism (in Khumjung), the indicators such as declining number of families involved in the transhumance systems, declining dependency on transhumance production and reduced involvement of young generations illustrate low resilience (van Oudenhoven *et al.* 2011) of transhumance systems. Furthermore, there were different interests from different stakeholders in the multi-functionality landscapes.

The future of the transhumance systems is likely to depend on how practitioners (transhumant herders) and policy makers perceive changes in the transhumance systems and likely impacts from such changes and their responses through policy decisions and practices. Moreover, various factors influence the responses of herders and policy makers making it difficult to predict future scenarios. The policy responses chosen can create different conditions and likely to affect these scenarios (Figure 7.2). In the situation where government policies promote other livelihood options, it will further discourage transhumant herders to practice transhunmance systems as they have been getting pressures from different drivers of change. In this situation, they may leave the traditional practices and follow other livelihood options. In the situation where government chooses to wait and see (do nothing), the transhumance systems could continue to decline in the face of different driving forces. Transhumance systems may not cease completely because it has integrated with crop production and most probably transhumant herders can choose more sedentary form of livestock production. In the situation where policies create competitive positions whereby transhumance improve income and living standard in comparison to other livelihood options, some level of transhumance could continue.

7.9. Key conceptual questions and findings of the study

Four key conceptual questions related to the transhumance systems that are not or partially answered were presented in chapter 2. These questions were general and a single study in a particular geographical areas and socio-economic context cannot fully answer those questions. However, any single study investigating all or some of those questions in any parts of the world contribute in the understanding of those key issues. The discussions on the findings on specific research questions and discussion presented above highlight its contribution in respect to mountainous areas of Nepal and the Himalayan region. The brief overview for how this study help in understanding conceptual questions in general is given below.

The findings on the drivers of changes in the transhumance systems indicated that the systems are experiencing change pressures from global to local levels. The ways how each of the drivers reach and influence transhumance systems are different. The effect from the global level drivers such as globalisation and climate change has intersected to the transhumant communities in different ways creating pressure directly or indirectly. The example of the direct pressure from these global process is the labour shortage due to involvement of family member in other profession such as tourism or labour migration. The indirect pressure is due to changing socio-economic and cultural context brought about by these forces. The national level drivers such as conservation and land management policies can be influenced by the global conservation momentum and the changes in the national policies and laws can limit the mobility of the transhumant herders which is the key feature of the transhumance systems. The country's political situation can affect such traditional SES as seen in one of the study area under this study. As transhumance systems is generally practiced in remote areas having difficulties to access, such local level factors could also discourage younger generations to involve in the system.

The available data for each type of livestock, number of people practicing transhumance and perceptions of transhumant herders generally indicated that the transhumance systems were declining. This was in line with many other traditional SESs and transhumance systems in different parts of the world as found in the review (given in chapter 2). However, it should be acknowledged that the declining trends, the main factors contributing to the trend differed across sites and each livestock types. Generally, the decline or loss of traditional SESs results to adverse socio-ecological impacts. As discussed earlier the changes or loss of transhumance systems may also lead to similar socio-ecological impacts, though it may lead to the better income opportunities and livelihood options in some cases. The possible social impacts from the loss of transhumance systems could be on livelihood of the people, loss of agricultural production, and loss of indigenous knowledge and culture. The possible ecological impacts associated with the loss of transhumance systems could be on biodiversity, land use and ecosystem services.

The response of transhumance systems and transhumant communities and their future scenarios largely depends on how policy makers perceive and respond to the socio-ecological impacts from the changes in the transhumance systems and practitioners perceive benefits from the systems. The policy responses and practitioners perceived benefit from the transhumance systems largely determine whether the transhumance continue and what form.

Chapter 8 : Key findings, research contributions and policy recommendations

8.1 Introduction

The overarching goal of this research was to examine the contemporary transhumance systems in the mountainous region of Nepal subjected to different change pressures. This covered study of contemporary transhumance systems including their socio-economic, cultural and ecological significances, contemporary drivers of change and pressures to the systems, major changes in the systems and social-ecological impacts from these changes. All of these aspects were covered in the earlier chapters. This chapter presents a summary of key findings, research contributions, policy recommendations and scopes for further research. First, key findings are summarised. Second, the contributions of the research are highlighted. Third, some policy recommendations are made. Finally, scopes for further research are given.

8.2 Key findings

The purposes of the research was to study (i) the current status of the transhumance systems and their socio-economic, cultural and ecological significances, (ii) the major drivers of changes to the transhumance systems, (iii) the major changes in the systems and (iv) the likely social and ecological impacts from the changes. Several specific objectives and complementary research questions were set up to fulfil those objectives and overarching goal of the research. The conclusion sections at the end of each result chapters (chapter 4 to 6) and discussion chapter (chapter 7) partly presented the findings on each objectives and specific research questions. This section presents the summary of key findings.

8.2.1 Status of transhumance systems and their socio-economic and cultural significances

Transhumance systems were still practised in the study areas. Though the dominant livestock type and herd size differed across sites, there were many commonalities in spatio-temporal pattern of migration. Transhumance was vertical in all sites whereby herders move livestock to the high altitude rangelands in the summer season and come down to the settlement and forest areas in the winter season. The seasonal movement of livestock were rational from both herders (production) and ecological (management) perspective. Herds were composed of different types of livestock to get multiple benefits.

Livestock production by means of transhumance was one of the major sources of HH's income in all sites. The contribution from livestock production was ranked first in Khumjung whereas it was second to agriculture in Kalinchok and Majhigaun. Herders have integrated transhumance grazing with crop production and both of these livelihood options were interdependent to each other. Furthermore, transhumant herders held traditional knowledge which was useful for herd and grazing management. Transhumance systems themselves evolved as a culture of local people and have socio-cultural significances. The findings suggest that the continuity of transhumance systems can contribute to the livelihood, socio-economy and culture.

8.2.2 Ecological role of transhumance systems

The findings from the ecological section revealed that the grazing disturbance gradients were developed from *goths* to the surroundings. With the increase in the distance from *goth*, there was a decrease in grazing intensity. The species richness (α-diversity) was lowest in the plots closest to *goths* where nitrophilous and grazing tolerant species were abundant. But the highest species richness per plot and the highest total number of species were found at mid or further distances (within 800 m transects) from *goths*. Rare species were also found at those distances. These results suggest that the adverse impacts of grazing were confined to very limited areas near *goths* and grazing seems to promote species richness at mid and farther distances from *goths*. These results do not support the notion that the livestock grazing is necessarily detrimental to the biodiversity in the Himalayan rangelands and do not encourage full cessation of transhumance grazing from the conservation point of view.

8.2.3 Major drivers of changes to the transhumance systems

8.2.3.1 Globalisation

Tourism and labour migration were considered as two factors under globalisation as they were relevant at least in one study area. In Khumjung/SNP where tourism was relevant, the livestock unit (LU) significantly differed between the HHs involved in tourism and those not involved in tourism. In two study sites, where labour migration was relevant, the nature of migration was different. In one site (Kalinchok/GCA), the destinations of migrants were other than India whereas in other site (Majhigaun/KNP), the destination was India. The LU was significantly higher in non-migrants HH than in migrants HHs (other than India). Though, the LU was slightly higher in non-migrants HH than in migrants (migrants to India) in Majhigaun, it was not significantly different. Tourism and labour migration have added pressure in two main ways; one by reducing labour availability and another by increasing HHs income. They have affected transhumance systems as many families either left traditional practices or reduced herd size and changed grazing patterns.

8.2.3.2 Conservation policies and practices

With the increase in conservation demand from the globally significant higher Himalaya, Nepal has been implementing different schemes of forest management and conservations where transhumance systems were historically practiced. However, the relationships between different schemes of conservation and transhumance systems were not satisfactory from the herders' perspective. The conservation policies and practices have reduced the operational freedom and flexibility of transhumant herders. Although Community Forest (CF) policies were more flexible and have devolved power to local user groups, the provisions that could accommodate transhumant herders were not implemented at local level. The policy to form Conservation Area Management Committee (CAMC) of Conservation Area (CA) at each Village Development Committee (VDC) following political boundaries of VDC's has potential to exclude herders from other VDCs. The National Park (NP) policies to allow grazing in designated areas and time could not meet the requirement of transhumance grazing and undermined the flexibility required to respond to nature's rhythm. Transhumant herders showed low positive perceptions and attitudes towards CF, CA and NP, high expectations for transhumance and related activities (graze livestock, move livestock, collect grass and fodder) in CF, CA and NP and low level of participations. These findings suggest that the relationships between conservation policies and practices and transhumance systems are not good, which could be counterproductive for both.

8.2.3.3 Climate change

Traditional social-ecological systems (TSESs) that are subject to accelerating change pressures from socio-economic changes and conservation might be further affected by climate change. Temperature showed increasing trends in all sites but there were different trends of precipitation across study sites. Majority of herders agreed that they have perceived changes in different biophysical indicators such as fast melting of snow in the rangelands, early onset of summer, emergence of new plant species in the rangelands, early growth of greenery in the rangelands, and early flowering/maturing of grasses in the rangelands. They might be related to climate change but they need to be monitored scientifically over time.

The changing trends of temperature and rainfall, and perceived change in the biophysical indicators by the herders have potential to affect all major components (rangelands, livestock and herders) of transhumance systems directly or indirectly. Furthermore, climate change is likely to combine with other socio-economic and political factors affecting the transhumance systems and will increase the vulnerability of the transhumant herders. The vulnerability to climate change and factors contributing for vulnerability differed across sites. The results also revealed that the vulnerability is largely influenced by socio-economic and non-climatic factors.

8.2.4 Major changes in the systems and social-ecological impacts

Herders had perceived that there was a decline in numbers of families practicing transhumance and a decreasing of herd size in all sites. Other perceived changes were in herd composition, grazing pattern, dependency on transhumance systems and involvement of the younger generation. However, the changes and reasons for change differed across sites. The loss or decline of transhumance systems is likely to have social and ecological impacts in the higher Himalayas. Effect on livelihood of transhumant herders, effect on agricultural production and loss of customary lifestyles, indigenous knowledge and culture are some of the possible social impacts. The ecological impacts are likely to be related to biodiversity, vegetation and land use and ecosystem function and services.

8.3 Research contributions

8.3.1 Contributions to literature

The study and documentation of social-ecological systems (SESs) are important as they are rapidly disappearing and are increasingly constrained by different factors. There was a lack of information about the current status of transhumance systems and their socio-economic, cultural and environmental (ecological) significances. Furthermore, how decline or loss of transhumance systems operates in the higher Himalayas i.e. what social and ecological impacts are likely with the decline or loss of transhumance system were also not known. Findings of this study helped to fulfil those knowledge gaps.

Poor understanding of the rangelands ecosystems in the Himalayas hindered informed decision making (Miller 1995). There was a lack of study about the ecological role of transhumance grazing in the Himalayan rangelands, however, there was a general perception that grazing has degraded rangelands and grazing is detrimental to the biodiversity conservation. This study assessed the effects of transhumance grazing to the plant species richness and composition in the study areas which contribute to resolve the existing perception and debate about the effect of grazing in the Himalayan rangelands.

In terms of theoretical perspective that I introduced in chapter two, this study contributes to the political ecology, landscape ecology and social-ecological systems (SESs) literature. The study contributes to literature related to the political ecology of scale because the study revealed how global or regional, national and local level factors were responsible for changes in the transhumance systems. The study also contributes literature related to the historical and cultural political ecology because the study has uncovered indigenous knowledge, traditions and culture associated with transhumance systems. As the Himalayan rangelands were subjected to transhumance grazing for centuries, it can contribute landscape ecology literature in general and cultural landscape literature in particular. The transhumance systems were studied as SESs and the study covered both social and ecological systems and contribute to the SESs literature.

In terms of methodology, the study of transhumance system as a SES is novel. The mixed methods allowed the integration of qualitative and quantitative data collected using tools and techniques from social as well as ecological science. The use of system thinking in general and Driver-Presure-State-Impact-Response (DPSIR) framework in particular provided an opportunity to understand the casual relationships and feedback between factors operating in the transhumance systems in an easily understandable way. Such an interdisciplinary approach can be useful for studying other traditional social-ecological systems (TSESs). The method adopted for vulnerability analysis provides the customised approach for the vulnerability assessment of other SESs. This method can also be easily replicated to study vulnerability of other, sectors and communities or to assess impacts of a programme or policy.

8.3.2 Contributions to policy and practice

The study has disclosed different aspects of transhumance systems which are useful to make a holistic decision about the transhumance systems. The findings on current status of transhumance systems and their socio-economic, cultural and ecological significances and likely social-ecological impacts from the decline or loss of transhumance systems, provide insight for policy makers whether to encourage or discourage transhumance systems in the higher Himalayas. The socio-economic and cultural significances of the systems in combination with the opportunities and threats from the global social and environmental changes help policy makers and practitioners to make decision whether or not to continue transhumance systems.

The findings of the ecological section also present some issues for the consideration of land management policy-makers in the high Himalayas. Most often, it is perceived that impacts of livestock grazing in the rangelands are negative, whereas, the impacts could be positive. The perception that rangelands are degraded due to overgrazing, and grazing is the major threat to biodiversity conservation in the Himalayan rangelands needs to be re-examined. On the one hand, herders perceived that the numbers of families as well as livestock involved in transhumance grazing are declining. On the other hand, the adverse effects of grazing were limited near *goths*, and in other zones grazing has promoted species richness and it has not threatened the rare species. Therefore, transhumance system should not only be seen purely as an economic activity of herders by policy makers, but its ecological roles need to be taken into account.

Community forests (CFs) and protected areas (PAs) policies of Nepal have attempted to devolve power to local people. However, some of the policies and more importantly the practices at local level have brought unintended outcomes to the transhumance systems. Some of the provisions that can accommodate transhumant herders and their issues are not implemented at the practical level. On the other side, transhumant herders showed low positive perceptions and attitudes, and participation towards different schemes of conservation (CF, CA and NP). These findings suggest that there is no harmonious relationship between conservation and transhumant herders. Such relationships indicate that there is room to improve policy and most importantly the practices at local level. The forest management and conservation policies should focus on how to avoid elite control and how to address the livelihood needs of highly resource dependent people such as transhumant herders. Policy makers should be mindful about the power relation within local people and the broader socio-economic and political setting which can prevent some people from taking advantage of devolution (Sikor & Nguyen 2007) and should look for options to address them.

The vulnerability analysis suggests the need for flexible policies to reduce climate change vulnerability. The improvement in the socio-economic factors such as availability of food, health facilities, and safe and consistent water supplies, social networks and diversification of livelihood activities increase adaptive capacity, reduce sensitivity and ultimately help to reduce vulnerability of transhumant herders. The findings will inform the design of policies and programmes to reduce vulnerability and enhance adaptive capacity of agrarian communities in general and the transhumant communities of the Himalayas in particular.

8.4 Policy recommendations

Considering socio-economic and cultural significances of transhumance (chapter 4), its ecological roles (chapter 5), and likely social-ecological impacts from the loss of systems (chapter 7), it is better if transhumance continue in the Himalayan region. The sustainable use and development of a multi-functional landscape needs to integrate social welfare and environmental conservation. Multi-functionality analysis helps to analyse trade-offs of each kind of landscapes use (Bolliger *et al.* 2011). The decisions of people living in remote mountainous areas whether or not to choose any livelihood option depends on how they perceive likelihood of improving living standard from that livelihood option compared to other available options. This again depends on the competitive position offered by livelihood options in rural economy and its comparative advantages. Therefore, it is essential to look at options to raise income from transhumance and improve the livelihood of people involved in transhumance systems. Instead of preservative strategies, policies should focus on transformative strategies (Fischer *et al.* 2012) that help local communities to develop a new sense of identity. The introduction of value addition technologies for livestock products, product branding (e.g. certification and labelling of transhumance products) and marketing (e.g. promotion of these products in tourism) can be one option to increase income from livestock production. Policy makers can categorise local people (households) according to the adoption of different types of livestock production system and government can provide support and incentives (if any are available) based on the livestock production methods they adopt.

The decisions to cease grazing in the rangelands based on indicators of localised overgrazing near livestock assembly points such as *goths* might be counter-productive as light grazing seems to promote species richness. However, there would need to be some strategy to reduce adverse effects very close to *goths*, if biodiversity is the goal. Rotation of *goths* locations in the rangelands can minimise the adverse impacts close to *goths* but the optimum time period for such rotation need to be investigated. Conservation policies should be more concerned with likely ecological impacts from grazing abandonment as it is likely in many areas that they are due to declining trends in response to accelerating change pressures. The ecological impacts from grazing abandonment are difficult to interpret and effects may vary with the scale of measurement (both spatial as well as temporal) and contextual factors. However, some likely impacts could be on biodiversity, vegetation and land use, and ecosystem function and services. Therefore, the functional links between transhumance grazing, biodiversity and land use in the high Himalayan rangelands should be the guiding principle to inform conservation policies and programmes. It should be remembered that transhumance systems involve land-extensive and non-extractive practices and transhumant herders are the principal agents whose decisions can affect the sustainability of such landscapes. Furthermore, it should be remembered that managing marginal environments such as higher Himalayas is particularly challenging because of heterogeneous landscape, harsh climate, low productivity and uncertainties related to tenure, markets and policies. Therefore, the use of livestock to control shrub encroachment and fire prevention could be of interest in the mountainous areas.

The role of traditional institutions, knowledge, practices and culture could be instrumental for the sustainability of traditional systems. Therefore, the local communities should be involved in central level rangeland planning, research and development. Supporting and strengthening existing institutions of transhumant herders such as those existing in Khumjung (*Nawa pratha*) and formulating new institutions to help herders to organise them. Preservation of traditional knowledge and practices, maintaining gene flow between livestock population and avoiding inbreeding are also important. The integrated knowledge systems that combine traditional knowledge and practices of herders with scientific tools and techniques might inform the design of institutions and policies. The inventions and technologies in rangeland science should be delivered to herders via trainings and workshops before intervention. Governmental and non-governmental organisations working to improve livelihood of local people and environmental conservation in the higher Himalayas can deliver new knowledge and inventions.

8.5 Scopes for future research

Further researchable issues are:

<u>Investigate more sites and in other countries</u>: This study tried to capture important variables affecting transhumance systems in the Himalayas. Given the limited resources and time, this study focused in three study sites. The replications of similar study in more sites within Nepal and in other countries helps for validation and better decision making.

<u>Investigate effect of grazing at different altitudes and vegetation</u>

The ecological role of transhumance grazing could be different in summer grazing areas (rangelands) and winter grazing areas (forests). This study examined the effect in the rangelands and effects on forests can be scope for further research.

Optimum grazing level: The findings of this study indicated that some level of grazing can promote species richness and composition in the Himalayan rangelands. However, the optimum grazing levels need to be studied. Establishing controlled plots or designing experiments with different grazing treatments to monitor species response help to precisely study the effect of grazing on the plant biodiversity.

Optimum rotation period (grazing management): One strategy to reduce adverse effects of grazing near *goths* can be the rotation of *goth* locations. However, the optimum time period for rotation needs to be tested. The differential response of vegetation to different livestock types needs to be considered.

Monitoring climate change impacts over time: This study highlighted perceived changes in biophysical indicators by herders due to climate change. However, the perceived changes and possible impacts of climate change to the transhumance systems need to be monitored scientifically over time.

Effectiveness and of local adaptation strategies: This study identified some local strategies of transhumant herders. Some of these strategies can help to better adapt with higher degree of climate change whereas others can be maladaptive. Therefore, the effectiveness of local adaptation strategies of transhumant herders to climate change needs to be scientifically tested and prioritised.

Ecosystem services from transhumance landscapes: Transhumance landscapes provide a numbers of ecosystem services. The policy decisions to encourage or cease transhumance systems based on limited understanding might affect ecosystem functions and services. Therefore, ecosystem services from those landscapes and how transhumant herders and transhumance systems are associated with them need to be investigated.

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Appendices

Appendix A

Livestock census form

Table A.1: Livestock census form

S.N.	Name of HHs head	Ward no. (village)	VDC	Number of							Total number	Practice transhumance*	
				Buffalo	Cow/ bull	Yak/ nak	*Chauri/jokpyo*	Goat	Sheep	Horse		Yes	No

*Graze livestock at least 3 months a year in the grazing areas that cannot be accessed in a daily basis

Appendix B

Questionnaire for household survey

You are invited to participate in the questionnaire survey of the research project entitled ***"Examining the transhumance system in the northern mountainous areas of Nepal under changing conservation paradigms and climate change"****. I am Suman Aryal, a PhD student at the University of Southern Queensland, Australia. The purpose of the survey is to collect information about the transhumance system in the northern mountainous areas of Nepal. The survey has been prepared solely for academic purposes. The survey will take about one hour to complete. Please, be informed that you have the right to withdraw from the project at any time without fear of the consequences (and take any previously provided information). I assure you that all information provided by you will be treated confidentially and will be only used for research purpose. If you are happy to participate in this questionnaire survey, please affix your signature and date in the plain language statement.*

Site: Code:

Name of Respondent (with surname):

Address (VDC/ward/settlement):

Date of interview: / / 2013 Age/Sex: Occupation:

Family size: Education (number of years):

Section 1: Socio-economy

1.1. Are you household's head?

i) Yes ii) No

If no, give the following details of HHs' head

Sex	Age	Education (no of years)

1.2. How many members of your family are in the following age group?

Age group	Below 16	16-59	Above 60
Number			

1.3. Do you have your own land?

i) Yes ii) No

If yes, give the information about the type of land your family owned

Types of land	Area (with unit)
Irrigated farm (*khet*)	
Rain feed farm (*bari*)	
Scrubland (*kharbari/pakho*)	
Forest (private)	
Other	
Total	

1.4. How long does food produced on the farm for your family last?

Specify (number of months): ....

1.5. What are the major crops that your family grow in your farm?

.... Total no of crops: ....

1.6. Which of the following specific activities contribute to your family's income? Please mention in figure.

SN	Activities/occupations	Annual income (NRs/year)	Remarks
1	Agriculture		
2	Livestock		
3	NTFPs and forest products		
4	Tourism (hotel/restaurant/tourism related business)		
5	Remittance		
6	Jobs (governmental/non-governmental)		
7	Labour portering		
8	Other (specify)		

1.7. Did your family borrow money from relatives or friends in the last month?

i) Yes ii) No

1.8. Did your family lend money to relatives or friends in the last month?

i) Yes ii) No

1.9. Does any member of your HHs work outside of the community?

i) Yes ii) No

If yes, give following details

Place	Within district	Outside district but within country	Abroad			Total
			India	Europe, America, Australia	Others	
Number						

1.10. Has anyone in your family been sick in last two weeks that they miss their work?

i) Yes ii) No

1.11. How do you treat members of your family who get sick?

i) Wait and see

ii) Go to witch doctors (*dhami/jhakri*)

iii) Go to traditional healers

iv) Go to health centre

1.12. How long does it take to go to the health centre?

Time (in day, hours, minute): ....

Section 2: Livestock and transhumance

2.1. Give details of the livestock type and number that your family ownes?

Type	**Total number**	**Male**	**Female**
Buffalo			
Cow/Ox/bull			
Sheep			
Goat			
Yak/Nak			
Hybrid (*chauri/jokpyo*)			
Horse			

2.2. Do you practice seasonal movement of livestock (transhumance) for grazing?

i) Yes ii) No

2.3. What is your level of agreement with the following statements about movement of livestock? *(Strongly agree= SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	**Statements**	**Level of agreement**				
	I practice seasonal movement of livestock	**SA**	**A**	**NAND**	**D**	**SD**
1	To adjust temperature (to avoid hot and cold)					
2	To avoid overgrazing in rangelands					
3	In search of grass availability					
4	In search of water availability					
5	To make it easy to sell off livestock and livestock products					
6	To adjust time of medicinal plant collection					

2.4. Are you member of any associations (such as herder committee)?

i) Yes ii) No

If yes, please mention what it is and what it does?

....

2.5. Are you involved in any cooperatives?

i) Yes ii) No

If yes, please mention what it does?

....

Section 3: Perceptions and attitudes, expectation and participation towards National Park (NP), Conservation Area (CA), and Community Forest (CF)

3.1. What is your level of agreement with following statements about National Park (specify national park SNP or KNP)? *(strongly agree= SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	Statement	Level of agreement				
		SA	A	NAND	D	SD
1	NP protect natural environment					
2	NP has benefited local people					
3	NP has increased income of local people					
4	NP has benefited livestock herders					
5	NP has not affected livestock herders					
6	NP has affected livestock rearing pattern					
7	NP has reduced livestock number					
8	NP has decreased livestock herders					
9	NP has increased livestock loss (predation)					
10	NP has increased crop damage due to wildlife					
11	NP should allow free grazing					
12	NP should allow collection of grass					
13	NP should provide route for livestock movement					
14	NP should allow seasonal grazing for traditional herders					
15	NP should allow collection of firewood					
16	NP should allow collection of wild fruits and vegetables					
17	NP should allow collection of medicinal plants					
18	I participate in the planning and implementation of different activities of NP					
19	I help NP					
20	I would like to be involved in development and management of NP					

3.2. What is your level of agreement with following statements about Gaurishanker Conservation Area (GCA) *(strongly agree= SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	Statement	Level of agreement				
		SA	A	NAND	D	SD
1	CA protect natural environment					
2	CA has benefited local people					
3	CA has increased income of local people					
4	CA has benefited livestock herders					
5	CA has not affected livestock herders					
6	CA has affected livestock rearing pattern					
7	CA has reduced livestock number					
8	CA has decreased livestock herders					
9	CA has increased livestock loss (predation)					
10	CA has increased crop damage due to wildlife					
11	CA should allow free grazing					
12	CA should allow collection of grass					
13	CA should provide route for livestock movement					
14	CA should allow seasonal grazing for traditional herders					
15	CA should allow collection of firewood					
16	CA should allow collection of wild fruits and vegetables					
17	CA should allow collection of medicinal plants					
18	I participate in the planning and implementation of different activities of CA					
19	I help CA					
20	I would like to be involved in development and management of CA					

3.3. Are you member of a Community Forest?

i) Yes ii) No

3.4. What is your level of agreement with following statements about Community Forest? *(strongly agree SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	Statement	Level of agreement				
		SA	A	NAND	D	SD
1	CF protect natural environment					
2	CF has benefited local people					
3	CF has increased income of local people					
4	CF has benefited livestock herders					
5	CF has not affected livestock herders					
6	CF has affected livestock rearing pattern					
7	CF has reduced livestock number					
8	CF has decreased livestock herders					
9	CF has increased livestock loss (predation)					
10	CF has increased crop damage due to wildlife					
11	CF should allow free grazing					
12	CF should allow collection of grass					
13	CF should provide route for livestock movement					
14	CF should allow seasonal grazing for traditional herders					
15	CF should allow collection of firewood					
16	CF should allow collection of wild fruits and vegetables					
17	CF should allow collection of medicinal plants					
18	I participate in the planning and implementation of different activities of CF					
19	I help CF					
20	I would like to be involved in development and management of CF					

3.5. Did you lose any livestock due to wildlife killing in the last 5 year?

i) Yes ii) No

If yes, please, give details

Livestock type	Number		Predator	Where*
	Adult	Young		
Buffalo				
Cow/ox				
Sheep				
Goat				
Yak/Nak				
Chauri/Jokpyo				

** Indicate: National Park/Conservation area=1, Buffer zone area=2, Community Forest area=3, National forest area=4, private land area=5)*

3.6. Do you think the next generation will continue livestock production in your family?

i) Yes ii) No

3.7. Why do you think so?

....

Section 4: Perceptions of herders towards climate change and tourism

4.1. Have you noticed any changes in following climatic variables as compared to past? If yes, how

Change in..	**Yes**	**No**	**Don't Know**	**If yes,**	
				Increased	**Decreased**
temperature of summer season					
temperature of winter season					
total amount of rainfall in a year					
total rainfall in monsoon season					
total rainfall in winter season					
amount of snowfall in a year					

4.2. What is your level of agreement with the following statements? *(strongly agree= SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	**Statement**	**Level of agreement**				
		SA	**A**	**NAND**	**D**	**SD**
1	Melting of snow in the grassland is faster					
2	Water sources are drying up					
3	There is increase in drought					
4	Early onset of summer					
5	Early growth of greenery in the rangelands					
6	Early flowering/maturing of plants in the rangelands					
7	New species of plants are appearing in rangelands					
8	New livestock diseases are appearing					
9	Grassland zones are shifting up					

4.3. Which is the most common natural disasters in your community?

i) Landslide ii) Avalanches iii) Drought iv) Heavy snowfall v) Other (specify)

4.4. How many times this area has been affected by landslides, drought, and extreme snowfall/rainfall, flood and avalanches, in last 5 years?

4.5. Do you receive a warning before natural disasters?

i) Yes ii) No

4.6. Was any member injured or died due to these events?

i) Yes ii) No

4.7. Was any livestock injured or died due to these events?

i) Yes ii) No

4.8. Where do you collect water from?

(i) Private tap ii) river iii) lake iv) pond iii) spring (kuwa)

4.9. Is this water available each day throughout the year?

i) Yes ii) No

4.10. Was there any conflict in the community for the use of water in the last year?

i) Yes ii) No

4.11. Do outsiders visit this area for entertainment?

i) Yes ii) No

If yes, who are most common?

(i) Foreigner ii) Nepalese iii) Both equal

4.12. What is your level of agreement with the following statements? *(strongly agree= SA, agree=A, neither agree nor disagree=NAND, disagree=D, strongly disagree=SD)*

S.N.	**Statement**	**Level of agreement**				
		SA	**A**	**NAND**	**D**	**SD**
1	Member/s of my family involved in tourism					
2	Tourism has increased HHs income					
3	I reduced number of livestock due to tourism					
4	Tourism has increased labour shortage for livestock production					
5	I used livestock for tourism purpose					
6	Tourism has reduced number of HHs rearing livestock					
7	Local products are promoted by tourism					
8	Our culture is strengthened by tourism					
9	I will be happy to see more tourists in the area					
10	I would like to be involved in tourism					

4.13. Did your family asked any assistance/support from local governments (VDC, forest related office, livestock related office, veterinary offices etc.) in the last year?

i) Yes ii) No

4.14. Did you or your family receive any help/support (like medical care or medicine, sell animal or animal products, veterinary facilities, caring of children or old persons) from relatives, friends, groups (club, committees), NGOs, government during difficult situations (extreme event)?

i) Yes ii) No

If yes, how many times did you receive such help/support?

....

4.15. Did you or your family provide any help/support (like medical care or medicine, sell animal or animal products, veterinary facilities, caring of children or old persons) to relatives, friends, groups (club, committees), NGOs, during difficult situations (extreme event)?

i) Yes ii) No

If yes, how many times did you provide receive such help/support?

....

Thank you for your valuable response and time.

Appendix C

Checklist for focus group discussions (FGDs)

1. Evolution of transhumance in the area
2. Purpose of rearing each types of livestock
3. Spatio-temporal pattern of migration (when and where they graze livestock)
4. Deciding date for seasonal movement
5. Cultural values and indigenous knowledge related to transhumance system
6. Trends or change in number of families practicing transhumance, number of each type of livestock, total herd size, livestock production and dependency, purpose of rearing livestock, grazing areas, routes and season, rangelands condition, involvement of young generation and labour availability
7. Implementation of NP, CA, CF and impacts to the transhumance system
8. Trends of globalisation (tourism, education, labour migration) and transhumance system
9. Climate change and impacts to the transhumance system
10. Major problems/threats of transhumance system and motivational factors (if any)

Appendix D

General characteristics of the respondents

Table D.1: General characteristics of the respondents

Characteristics	Site		
	SNP/ Khumjung(n=37)	**GCA/ Kalinchok(n=54)**	**KNP/ Majhigaun (n=54)**
Gender	M=25, F=12	M=31, F=23	M=34, F=20
Average Age (years)	53.79	54.93	52.54
Average education (no of years)	1.84	1.19	1.46
Average family size	5.89	6.13	6.57
Average no of livestock per HH	23.59	16.33	15.87
Average LU per HH	7.4	4.8	5.5
Average no of crops grown per family	2.48	4.27	3.7
Average no of months the HHs food production lasts for	4.21	5.9	6.57
Average no of HHs income sources	3.38	2.89	3.5

Appendix E

Species profile

Table E.1: Species profile for Sagarmatha National Park (SNP)

SN	Name of species	Family	Abbreviation	Life form	Elevation range
1	*Acer pectinatum*	Araceae	*Acer pec*	Herb	2700-3800
2	*Aconitum spicatum*	Ranunculaceae	*Acon spi*	Herb	3300-4300
3	*Allium wallichii*	Amaryllidaceae	*Alli wal*	Herb	2400-4650
4	*Anaphalis busua*	Compositae	*Anap bus*	Herb	1500-2900
5	*Anaphalis carvei*	Ranunculaceae	*Anap car*	Herb	*
6	*Androsace globifera*	Primulaceae	*Andr glo*	Herb	3600-4500
7	*Anemone demissa*	Ranunculaceae	*Anem dem*	Herb	3300-4500
8	*Anemone rivularis*	Ranunculaceae	*Anem riv*	Herb	1600-4000
9	*Anemone rupicola*	Ranunculaceae	*Anem rup*	Herb	2700-4300
10	*Arisaema jacquemontii*	Araceae	*Aris jac*	Herb	2700-4000
11	*Arisaema propinquum*	Araceae	*Aris pro*	Herb	2400-3600
12	*Artemisia sp*	Compositae	*Arte sp*	Shrub	**
13	*Aster diplostephioides*	Compositae	*Aste dip*	Herb	3300-4800
14	*Aster sp*	Compositae	*Aste sp*	Herb	**
15	*Astragalus candolleanus*	Leguminosae	*Astr can*	Shrub	2700-4500
16	*Berberis aristata*	Berberidaceae	*Berb ari*	Shrub	1800-3000
17	*Berberis mucrifolia*	Berberidaceae	*Berb muc*	Shrub	2100-4500
18	*Bistorta milletii*	Polygonaceae	*Bist mil*	Herb	3000-3400
19	*Calamagrostis sp*	Poaceae	*Cala sp*		**
20	*Calanthe alpina*	Orchidaceae	*Cala alp*	Herb	*
21	*Caltha paulstris*	Ranunculaceae	*Calt pau*	Herb	2400-4000
22	*Caragana brevifolia*	Leguminosae	*Cara bre*	Shrub	3300-4500
23	*Carex sp*	Cyperaceae	*Care sp*		**
24	*Cassiope fastigiata*	Ericaceae	*Cass fas*	Shrub	2800-5000
25	*Chesneya nubigena*	Leguminosae	*Ches nub*	Herb	3600-5200
26	*Cirsium falconeri*	Compositae	*Cirs fal*	Herb	2700-4300
27	*Corydalis govaniana*	Papaveraceae	*Cory gov*	Shrub	2400-4800

SN	Name of species	Family	Abbreviation	Life form	Elevation range
28	*Corydalis juncea*	Papaveraceae	*Cory jun*	Herb	2500-5100
29	*Cotoneaster microphyllus*	Rosaceae	*Coto mic*	Shrub	2000-5400
30	*Cuscuta reflexa*	Convolvulaceae	*Cusc ref*	Herb	600-3300
31	*Cyananthus lobatus*	Campanulaceae	*Cyna lob*	Shrub	3300-4500
32	*Cynanthus microphyllus*	Campanulaceae	*Cyna mic*	Herb	2900-4800
33	*Cyperus rotundus*	Cyperaceae	*Cype rot*		*
34	*Cyperus sp*	Cyperaceae	*Cype sp*		**
35	*Ephedra gerardiana*	Ephedraceae	*Ephe ger*	Shrub	3700-5100
36	*Euphorbia stracheyi*	Euphorbiaceae	*Euph str*	Herb	2000-5000
37	*Euphorbia wallichii*	Euphorbiaceae	*Euph wal*	Herb	2300-3600
38	*Fagopyrum esculentum*	Polygonaceae	*Fago esc*	Herb	2000-4400
39	*Fragaria nubicola*	Rosaceae	*Frag nub*	Herb	1600-4000
40	*Fritillaria cirrhosa*	Liliaceae	*Frit cir*	Herb	3000-4600
41	*Gaultheria trichophylla*	Ericaceae	*Gault tri*	Shrub	2700-4500
42	*Gentiana depressa*	Gentianaceae	*Gent dep*	Herb	2900-4300
43	*Gentiana ornata*	Gentianaceae	*Gent orn*	Herb	3600-5500
44	*Geranium donianum*	Geraniaceae	*Gera don*	Herb	3200-3800
45	*Gerbera nivea*	Compositae	*Gerb niv*	Herb	2800-4500
46	*Gueldenstaedtia himalaica*	Coriariceae	*Guel him*	Herb	330-4600
47	*Heracleum sp*	Apiaceae	*Hera sp*	Herb	**
48	*Hippophae tibetana*	Elaeangnaceae	*Hipp tib*	Shrub or tree	3300-4500
49	*Iris goniocarpa*	Iridaceae	*Iris gon*	Herb	3600-4400
50	*Juncus thomsonii*	Juncaceae	*Junc tho*	Herb	2700-5200
51	*Juniperus indica*	Cupressaceae	*Juni ind*	Shrub or tree	3700-4100
52	*Juniperus recurva*	Cupressaceae	*Juni rec*	Shrub or tree	2500-4600
53	*Juniperus squamata*	Cupressaceae	*Juni squ*	Shrub or tree	3300-4400
54	*Kobresia fissiglumis*	Cyperaceae	*Kobr fis*		*
55	*Kobresia nepalensis*	Cyperaceae	*Kobr nep*		*
56	*Lilium nanum*	Liliaceae	*Lili nan*	Herb	3700-4600
57	*Lonicera spinosa*	Caprifoliaceae	*Loni spi*	Shrub	3600-4600
58	*Morina nepalensis*	Dipsacaceae	*Mori nep*	Herb	3000-4500
59	*Parnassia nubicola*	Parpnassiaceae	*Parn nub*	Herb	3000-4300
60	*Parochetus communis*	Leguminosae	*Paro com*	Herb	900-4000
61	*Pedicularis elwesii*	Scrophulariaceae	*Pedi elw*	Herb	3600-4800
62	*Pedicularis scullyana*	Scrophulariaceae	*Pedi scu*	Herb	3300-4800
63	*Pedicularis sp*	Scrophulariaceae	*Pedi sp*		**
64	*Persicaria polystachya*	Polygonaceae	*Persi pol*	Herb	2700-4200
65	*Poa harare*	Poaceae	*Poa har*	Herb	*
66	*Poa sp*	Poaceae	*Poa sp*		**
67	*Polygonatum hookeri*	Liliaceae	*Poly hoo*	Herb	3300-5000
68	*Potentialla microphylla*	Rosaceae	*Pote mic*	Herb	3800-5100
69	*Potentilla cirrhifolium*	Rosaceae	*Pote cir*		*
70	*Potentilla cuneata*	Rosaceae	*Pote cun*	Herb	2400-4900
71	*Potentilla eriocarpa*	Rosaceae	*Pote ero*	Shrub	3000-5000
72	*Potentilla fruticosa*	Rosaceae	*Pote fru*	Herb or shrub	2700-4300
73	*Potentilla peduncularis*	Rosaceae	*Pote ped*	Herb	3000-4700
74	*Primula denticulata*	Primulaceae	*Prim den*	Herb	1500-4900

SN	Name of species	Family	Abbreviation	Life form	Elevation range
75	*Primula sikkimensis*	Primulaceae	*Prim sik*	Herb	3300-4400
76	*Ranunculus brotherusii*	Ranunculaceae	*Ranu bro*	Herb	3000-5000
77	*Ranunculus pulchellus*	Ranunculaceae	*Ranu pul*	Herb	3600-4900
78	*Rheum australe*	Polygonaceae	*Rheu ast*	Herb	3000-4200
79	*Rhododendron anthopogan*	Ericaceae	*Rhod ant*	Shrub	3300-5100
80	*Rhododendron cowanianum*	Ericaceae	*Rhod cow*	Shrub	3000-3900
81	*Rhododendron lepidotum*	Ericaceae	*Rhod lep*	Shrub	2100-4700
82	*Rosa sericea*	Rosaceae	*Rosa ser*	Shrub	2100-4500
83	*Roscoea alpina*	Zingiberaceae	*Rosc alp*	Herb	2400-3100
84	*Rumex nepalensis*	Polygonaceae	*Rume nep*	Herb	1200-4200
85	*Salix calyculata*	Salicaceae	*Sali cal*	Shrub	3400-4400
86	*Sassurea sp*	Compositae	*Sass sp*		**
87	*Saussurea gossypiphora*	Compositae	*Saus gos*	Herb	4300-5600
88	*Selinum wallichianum*	Compositae	*Seli wal*	Herb	2700-3300
89	*Sexifraga roylei*	Sexifragaceae	*Sexi roy*	Herb	3300-3800
90	*Smilacina purpurea*	Liliaceae	*Smil pur*	Herb	2400-4200
91	*Spiraea canescens*	Rosaceae	*Spir can*	Shrub	1500-3200
92	*Stipa sp*	Poaceae	*Stip sp*		**
93	*Sunipia bicolor*	Orchidaceae	*Suni bic*	Herb	900-2700
94	*Swertia sp*	Gentianaceae	*Swer sp*	herb	**
95	*Thalictrum alpinum*	Ranunculaceae	*Thal alp*	Herb	2800-5000
96	*Thalictrum reniforme*	Ranunculaceae	*Thal ren*	Herb	2800-3300
97	*Thalictrum sp*	Ranunculaceae	*Thal sp*	Herb	**
98	*Trifolium repens*	Leguminosae	*Trif rep*	Herb	1500-2500
99	*Trigonella emodi*	Leguminosae	*Trig emo*	Herb	1300-4900

*= Elevation range not found, **= Identified to genus only, ***= Not identified

Table E.2: Species profile for Gaurishakar Conservation Area (GCA)

SN	Name of species	Family	Abbreviation	Life form	Elevation range
1	*Allium wallichii*	Amaryllidaceae	*Alli wal*	Herb	2400-4650
2	*Anaphalis busua*	Compositae	*Anap bus*	Herb	1500-2900
3	*Anemone rivularis*	Ranunculaceae	*Anem riv*	Herb	1600-4000
4	*Arisaema jacquemontii*	Araceae	*Aris jac*	Herb	2700-4000
5	*Artemisia indica*	Compositae	*Arte ind*	Shrub	*
6	*Asparagus recemosus*	Liliaceae	*Aspa rec*	Shrub	600-2100
7	*Aster diplostephioides*	Compositae	*Aste dip*	Herb	3300-4800
8	*Astragalus sp*	Leguminosae	*Astr sp*	Shrub or herb	**
9	*Berberis angulosa*	Berberidaceae	*Berb ang*	Shrub	3400-4500
10	*Berberis aristata*	Berberidaceae	*Berb ari*	Shrub	1800-3000
11	*Bidens pilosa*	Asteraceae	*Bide pil*	Herb	*
12	*Bistorta milletii*	Polygonaceae	*Bist mil*	Herb	3000-3400
13	*Caltha paulstris*	Ranunculaceae	*Calt pau*	Herb	2400-4000
14	*Centella asiatica*	Apiaceae	*Cent asi*	Herb	500-2100
15	*Cirsium falconeri*	Compositae	*Cirs fal*	Herb	2700-4300
16	*Cortiella hookeri*	Umbelliferae	*Cort hoo*	Herb	2500-5100
17	*Corydalis juncea*	Papaveraceae	*Cory jun*	Herb	2500-5100
18	*Cotoneaster microphyllus*	Rosaceae	*Coto mic*	Shrub	2000-5400
19	*Cynodon dactylon*	Poaceae	*Cyno dec*		*
20	*Cyperus rotundus*	Cypraceae	*Cype rot*		*

SN	Name of species	Family	Abbreviation	Life form	Elevation range
21	*Cyperus sp.*	Cypraceae	*Cype sp*		**
22	*Daphne bholua*	Thymelaeaceae	*Daph bho*	Shrub	1800-3100
23	*Digitaria setigera*	Poaceae	*Digi set*		*
24	*Ephedra gerardiana*	Ephedraceae	*Ephe ger*	Shrub	3700-5200
25	*Euphorbia wallichii*	Euphorbiaceae	*Euph wal*	Shrub	2300-3600
26	*Euphrasia himalayica*	Solanaceae	*Euph him*	Herb	1600-4000
27	*Fragaria nubicola*	Rosaceae	*Frag nub*	Herb	1600-4000
28	*Fritillaria cirrhosa*	Liliaceae	*Frit cir*	Herb	3000-4600
29	*Gaultheria fragrantissima*	Ericaceae	*Gaul fra*	Shrub	1500-2700
30	*Gentianna depressa*	Gentianaceae	*Gent dep*	Herb	3300-4300
31	*Geranium nepalensis*	Geraniaceae	*Gera nep*	Herb	*
32	*Geranium polyanthes*	Geraniaceae	*Gera pol*	Shrub	2400-4500
33	*Gerbera nivea*	Compositae	*Gerb niv*	Herb	2800-4500
34	*Girardinia diversifolia*	Urticaceae	*Gira div*	Shrub	1200-3000
35	*Heracleum sp*	Apiaceae	*Hera sp*	herb	**
36	*Impatiens sulcata*	Balsaminaceae	*Impa sul*	Herb	1700-4100
37	*Imperata cylindrica*	Poaceae	*Impe cyl*		*
38	*Iris goniocarpa*	Iridaceae	*Iris gon*	Herb	3600-4600
39	*Juniperus indica*	Cupressaceae	*Juni ind*	Shrub or tree	3700-4100
40	*Juniperus squamata*	Cupressaceae	*Juni squ*	Shrub or tree	3700-4600
41	*Kobresia nepalensis*	Cypraceae	*Kobr nep*		*
42	*Lilium nanum*	Liliaceae	*Lili nan*	Herb	3700-4600
43	*Lomatogonium sp.*	Gentianaceae	*Loma sp*	Herb	**
44	*Lonicera spinosa*	Caprifoliaceae	*Loni spi*	Shrub	3600-4600
45	*Mimosa pudica*	Leguminosae	*Mimo pud*	Shrub	*
46	*Morina nepalensis*	Dipsacaceae	*Mori nep*	herb	3000-4500
47	*Oxalis corniculata*	Oxalidaceae	*Oxal cor*	Herb	2100-3000
48	*Paris polyphylla*	Liliaceae	*Pari pol*	Herb	2000-3000
49	*Pedicularis elwesii*	Scrophulariaceae	*Pedi elw*	Herb	3600-4800
50	*Plantago major*	Plantaginaceae	*Plan maj*	Herb	*
51	*Poa sp.*	Poaceae	*Poa sp*		**
52	*Polygonatum hookeri*	Liliaceae	*Poly hoo*	Herb	3300-5000
53	*Potentilla cuneata*	Rosaceae	*Pote cun*	Herb	2400-4900
54	*Potentilla microphylla*	Rosaceae	*Pote mic*	Herb	3800-5100
55	*Potentilla peduncularis*	Rosaceae	*Pote ped*	Herb	3000-4700
56	*Primula denticulata*	Primulaceae	*Prim den*	Herb	1500-4900
57	*Primula sikkimensis*	Primulaceae	*Prim sik*	Herb	3300-4800
58	*Pyracantha crenulata*	Rosaceae	*Pyra cre*	Shrub	1000-2400
59	*Pyrus pashia*	Rosaceae	*Pyru pas*	Shrub	750-2700
60	*Ranunculus brotherusii*	Ranunculaceae	*Ranu bro*	Herb	3000-5000
61	*Ranunculus pulchellus*	ranunculaceae	*Ranu pul*	Herb	3600-4900
62	*Rheum australe*	Polygonaceae	*Rheu ast*	Herb	3000-4200
63	*Rheum nobile*	Polygonaceae	*Rheu nob*	Herb	3600-4500
64	*Rhodendron lepidotum*	Ericaceae	*Rhod lep*	Shrub	Shrub
65	*Rhododendron anthopogan*	Ericaceae	*Rhod ant*	Shrub	3300-5100
66	*Rhododendron barbatum*	Ericaceae	*Rhod bar*	Shrub	2400-3600
67	*Rhododendron campanulatum*	Ericaceae	*Rhod com*	Shrub	3000-4400
68	*Rosa macrophylla*	Rosaceae	*Rosa mic*	Shrub	2100-3800
69	*Roscoea alpina*	Zingiberaceae	*Rosc alp*	Herb	2500-4000
70	*Rumex nepalensis*	Polygonaceae	*Rume nep*	Herb	1200-4200

SN	Name of species	Family	Abbreviation	Life form	Elevation range
71	*Salix calyculata*	Salicaceae	*Sali cal*	Shrub	3600-4300
72	*Saussurea gossypiphora*	Compositae	*Saus gos*	Herb	4300-5600
73	*Senecio chrysanthemoides*	Compositae	*Sene chr*	Herb	2400-4000
74	*Sexifraga parnassifolia*	Sexifragaceae	*Sexi par*	Shrub	1900-4500
75	*Swertia sp.*	Gentianaceae	*Swer sp*	Herb	**
76	*Thalictrum alpinum*	Ranunculaceae	*Thal alp*	Herb	2800-5000
77	*Trifolium repens*	Leguminosae	*Trif rep*	Herb	1500-2500
78	Unknown 1		*Unkn 1*		***
79	*Utrica hyperborea*	Urticaceae	*Utri hyp*	Herb	4100-5100
80	*Viola biflora*	Violaceae	*Viol bif*	Herb	2100-4500
81	*Zanthoxylum armatum*	Rutaceae	*Zant arm*	Shrub	1100-2500

*= Elevation range not found, **= Identified to genus only, ***= Not identified

Table E.3: Species profile for Khaptad National Park (KNP)

SN	Name of species	Family	Abbreviation	Life form	Elevation range
1	*Ageratum conyzoides*	Compositae	*Ager con*	Herb	to 2000m
2	*Allium wallichii*	Amaryllidaceae	*Alli wal*	Herb	2400-4650
3	*Anaphalis busua*	Compositae	*Anap bus*	Herb	1500-2900
4	*Androsace primuloides*	Primulaceae	*Andr pri*	Herb	3000-4000
5	*Androsace strigillosa*	Primulaceae	*Andr str*	Herb	2400-4300
6	*Anemone rivularis*	Ranunculaceae	*Anem riv*	Herb	2100-3600
7	*Anemone rupicola*	Ranunculaceae	*Anem rup*	Herb	2700-4300
8	*Arisaema jacquemontii*	Araceae	*Aris jac*	Herb	2700-4000
9	*Artemisia indica*	Compositae	*Arte ind*	Herb	300-2500
10	*Arundinaria falcata*	Poaceae	*Arun fal*		*
11	*Arundinaria maling*	Gramineae	*Arun mal*		1200-2100
12	*Aster sp.*	Compositae	*Aste sp*	Herb	**
13	*Astragalus floridus*	Leguminosae	*Astr flo*	Herb	4200-4700
14	*Berberis angulosa*	Berberidaceae	*Berb ang*	Shrub	3400-4500
15	*Berberis aristata*	Berberidaceae	*Berb ari*	Shrub	1800-3000
16	*Berberis mucrifolia*	Berberidaceae	*Berb muc*	Shrub	2100-4500
17	*Bistorta macrophylla*	Polygonaceae	*Bist mic*	Herb	1700-4500
18	*Bistorta milletii*	Polygonaceae	*Bist mil*	Herb	3000-3400
19	*Caragana brevifolia*	Leguminosae	*Cara bre*	Shrub	3300-4500
20	*Caryx sp.*	Cyperaceae	*Cary sp*		*
21	*Cassiope fastigiata*	Ericaceae	*Cass fas*	Shrub	2800-4500
22	*Centella asiatica*	Apiaceae	*Cent asi*	Herb	500-2100
23	*Cirsium falconeri*	Compositae	*Cirs fal*	Herb	2700-4300
24	*Cortiella hookeri*	Umbeliferae	*Cort hoo*	Herb	4300-5500
25	*Corydalis juncea*	Papaveraceae	*Cory jun*	Herb	2500-5100
26	*Cotoneaster microphylus*	Rosaceae	*Coto mic*	Shrub	2000-5400
27	*Cynodon dactylon*	Poaceae	*Cyno dec*		*
28	*Cynoglossum sp.*	Boraginaceae	*Cyno sp*	Herb	**
29	*Cyperus cuspidatus*	Cyperaceae	*Cype cus*		*
30	*Cyperus rotundus*	Cyperaceae	*Cype rot*		*

SN	Name of species	Family	Abbreviation	Life form	Elevation range
31	*Cyperus sp.*	Cyperaceae	*Cype sp*		**
32	*Cypripedium cordigerum*	Orchidaceae	*Cypr cor*	Shrub	2100-4000
33	*Cypripedium himalaicum*	Orchidaceae	*Cypr him*	Herb	3000-4300
34	*Dactylorhiza hatagirea*	Orchidaceae	*Dact hat*	Herb	2800-4000
35	*Equisetum arvense*	Pteridophytes	*Equi arv*		*
36	*Eragrostis pilosa*	Poaceae	*Erag pil*		*
37	*Euphorbia helioscopia*	Euphorbiaceae	*Euph hel*	Herb	300-1800
38	*Euphorbia wallichii*	Euphorbiaceae	*Euph wal*	Herb	2300-3600
39	*Fragaria nubicola*	Rosaceae	*Frag nub*	Herb	1600-4000
40	*Fritillaria cirrhosa*	Liliaceae	*Frit cir*	Herb	3000-4600
41	*Gentiana depressa*	Gentianaceae	*Gent dep*	Herb	2900-4300
42	*Geranium nakaoanum*	Geraniaceae	*Gera nak*	Herb	3300-4500
43	*Gerbera nivea*	Compositae	*Gerb niv*	Herb	2800-4500
44	*Geum elatum*	Rosaceae	*Geum ela*	Herb	2700-4300
45	*Gnaphalium affine*	Compositae	*Gnap aff*	Herb	1200-3000
46	*Heraceleum sp*	Apiaceae	*Hera sp*	Herb	
47	*Iris nepalensis*	Iridaceae	*Iris nep*	Herb	1800-4400
48	*Juncus cuspidatus*	Juncaceae	*Junc cus*	Herb	*
49	*Kobresia nepalensis*	Cyperaceae	*Kobr nep*		*
50	*Lotus corniculatus*	Leguminosae	*Lotu cor*	Herb	3000-3700
51	*Meconopsis simplicifolia*	Papaveraceae	*Meco sim*	Herb	3300-4500
52	*Mimosa pudica*	Leguminosae	*Mimo pud*	Shrub	to 1900
53	*Morina nepalensis*	Dipsacaceae	*Mori nep*	Herb	3000-4500
54	*Oxalis corniculata*	Oxalidaceae	*Oxal cor*	Herb	to 2800
55	*Parochetus communis*	Leguminosae	*Paro com*	Herb	900-4000
56	*Pedicularis hoffmeisteris*	Scrophulariaceae	*Pedi hof*	Herb	2500-4500
57	*Pedicularis longiflora*	Scrophulariaceae	*Pedi lon*	Herb	2700-4800
58	*Pedicularis oederi*	Scrophulariaceae	*Pedi oed*	Herb	3600-4800
59	*Pedicularis scullyana*	Scrophulariaceae	*Pedi scu*	Herb	3300-4800
60	*Piptanthus nepalensis*	Leguminosae	*Pipt nep*	Shrub	2100-3600
61	*Plantago majors*	Plantaginaceae	*Plan maj*	Herb	*
62	*Poa sp*	Poaceae	*Poa sp*		**
63	*Polygonatum verticillatum*	Liliaceae	*Poly ver*	Herb	1500-3700
64	*Potentilla atrosanguinea*	Rosaceae	*Pote atr*	Herb	2400-4500
65	*Potentilla cuneata*	Rosaceae	*Pote cun*	Herb	2400-4900
66	*Potentilla eriocarpa*	Rosaceae	*Pote eri*	Herb	3000-5000
67	*Potentilla microphylla*	Rosaceae	*Pote mic*	Herb	3800-5100
68	*Potentilla peduncularis*	Rosaceae	*Pote ped*	Herb	3000-4700
69	*Primula denticulata*	Primulaceae	*Prim den*	Herb	1500-4900
70	*Primula glomerata*	Primulaceae	*Prim glo*	Herb	3000-5000

SN	Name of species	Family	Abbreviation	Life form	Elevation range
71	*Primula reptans*	Primulaceae	*Prim rep*	Herb	3600-5500
72	*Primula sikkimensis*	Primulaceae	*Prim sik*	Herb	3300-4400
73	*Prunus nepaulensis*	Rosaceae	*Prun nep*	Shrub	1200-2600
74	*Ranunculus brotherusii*	Ranunculaceae	*Ranu bro*	Herb	3000-5000
75	*Ranunculus diffusus*	Ranunculaceae	*Ranu dif*	Herb	1500-4000
76	*Ranunculus hirtellus*	Ranunculaceae	*Ranu hir*	Herb	3000-4800
77	*Ranunculus pulchelus*	Ranunculaceae	*Ranu pul*	Herb	3600-4900
78	*Ranunculus tricuspis*	Ranunculaceae	*Ranu tri*	Herb	3300-4400
79	*Rhododendron anthopogan*	Ericaceae	*Rhod ant*	Shrub	3300-5100
80	*Rhododendron lepidotum*	Ericaceae	*Rhod lep*	shrub	2100-4700
81	*Rosa sericea*	Rosaceae	*Rosa ser*	Shrub	2100-4500
82	*Roscoea alpina*	Zingiberaceae	*Rosc alp*	Herb	2500-4000
83	*Roscoea purpurea*	Zingiberaceae	*Rosc pur*	Herb	1500-3000
84	*Rubus foliolosus*	Rosaceae	*Rubu fol*	Shrub	2100-3600
85	*Rumex nepalensis*	Polygonaceae	*Rume nep*	Herb	1200-4200
86	*Salix calyculata*	Salicaceae	*Sali cal*	Shrub	3600-4300
87	*Saussurea nepalensis*	Compositae	*Sasu nep*	Herb	3200-4900
88	*Saxifraga sibirica*	Sexifragaceae	*Sexi sib*	Herb	3000-5000
89	*Selinum tenuifolium*	Umbeliferae	*Seli ten*	Herb	2700-4000
90	*Senecio chrysanthemoides*	Compositae	*Sene chr*	Herb	2400-4000
91	*Smilacina purpurea*	Liliaceae	*Smil pur*	Herb	2400-4200
92	*Stipa sp.*	Poaceae	*Stip sp*		**
93	*Swertia angustifolia*	Gentianaceae	*Swer ang*	Herb	600-2700
94	*Teraxacum tibetianum*	Compositae	*Tera tib*	Herb	4000-4300
95	*Thalictrum alpinum*	Ranunculaceae	*Thal alp*	Herb	2800-5000
96	*Thalictrum reiniforme*	Ranunculaceae	*Thal rei*	Herb	2800-3300
97	*Thesium chinensis*	Santalaceae	*Thes chi*	Herb	*
98	*Trifolium repens*	Leguminosae	*Trif rep*	Herb	1500-2500
99	Unknown 1		*Unkn 1*		***
100	Unknown 2		*Unkn 2*		***
101	Unknown 3		*Unkn 3*		***
102	*Viola biflora*	Violaceae	*Viol bif*	Herb	2100-4500

*= Elevation range not found, **= Identified to genus only, ***= Not identified

Appendix F
Descriptive statistics of environmental variables

Table F.1: Descriptive statistics for environmental variables for Sagarmatha National Park (SNP), Gaurishankar Conservation Area (GCA) and Khaptad National Park (KNP)

	SNP				GCA				KNP				Combined			
Environmental variable	**Min**	**Mean**	**Max**	**SD**	**Min**	**Mean**	**Max**	**SD**	**Min**	**Mean**	**Max**	**SD**	**Min**	**Mean**	**Max**	**SD**
Alti	3982	4241	4405	159.4	3350	3401	3509	64.21	3002	3036	3101	36.98	3002	3519	4405	514
Dist	25	310.7	800	279.6	25	310.7	800	279.56	25	310.7	800	279.05	25	310.7	800	277.82
Slop	0	3.03	9	2.65	0	1.67	-6	2.27	0	2.08	9	2.6	0	2.25	9	2.57
PH	6	6.64	6.8	0.12	6.5	6.6	6.8	0.08	6.3	6.6	6.8	0.1	6	6.65	6.8	0.1
Mois	2	4.39	7	1.28	4	5.01	6.5	0.56	3	6.04	8	1.31	2	5.21	8	1.32
Shrc	0	25.8	50	13.03	0	4.28	15	4.41	0	4.78	50	8.27	0	11.1	50	13.42
Grvc	15	44.73	75	13.59	60	74.82	85	6.17	47	78.39	90	7.9	15	66.93	90	17.7
Rocc	0	8.75	35	9	0	1.44	10	2.8	0	1.85	20	4.09	0	3.85	35	6.64
Graz	-4.2	0	3.14	1.74	-4.15	0	3.45	1.74	-4.56	0	3.24	1.74	-4.56	0	3.45	1.73
Baso	0	20.36	55	12.57	5	19.45	35	6.66	3	14.97	20	6.36	0	18.01	55	9.1
Dung	0	2.42	4	1.02	0	1.76	4	0.89	0	2.54	4	1.08	0	2.26	4	1.06
Tram	0	1.87	4	1.01	0	2.08	4	0.99	0	1.71	4	1.1	0	1.9	4	1.04
Humd	0	0.58	1	0.49	0	0.44	1	0.5	0	0.45	1	0.5	0	0.49	1	0.5
Wild	0	0.44	1	0.5	0	0.26	1	0.44	0	0.3	1	0.46	0	0.33	1	0.47
Tons	9	1.86	17	1.58	14	18.96	23	2.57	10	15.8	22	2.36	9	15.87	23	3.26

Note: Alti = Altitude (m asl), Dist = Distance from Goth, Slop = Slope, Mois = Moisture, Shrc = Shrub cover (%), Grvc = Ground vegetation cover (%), Rocc = Rock cover (%), Graz = Grazing, Baso = Bare soil (%), Tram = Trampling, Humd = Human disturbance, Wild = Wildlife disturbance, Tons = Total number of species

Appendix G

Correlation between environmental variables

Table G.1: Correlation between environmental variables for Sagarmatha National Park (SNP)

	Alti	**Dist**	**Slop**	**PH**	**Mois**	**Shrc**	**Grvc**	**Rocc**	**Graz**	**Baso**	**Dung**	**Tram**	**Humd**	**Wild**	**Tons**
Alti	1	0	-0.47	0.18	-0.17	-0.23	0.17	-0.49	0.12	0.18	0.01	-0.09	0.01	0.84	0.08
Dist		1	0.33	-0.04	-0.04	0.27	0.17	0.02	-0.63	-0.32	-0.69	-0.6	-0.18	-0.04	0.5
Slop			1	-0.14	-0.44	0.19	0.08	0.03	-0.41	-0.32	-0.33	-0.2	-0.14	-0.16	0.13
PH				1	0	0	-0.11	-0.11	0.03	0.09	0.02	0.09	-0.17	0.03	-0.07
Mois					1	0.11	-0.31	0.3	0.26	0.19	0.19	0.05	4	0.12	0.026
Shrc						1	-0.44	0	-0.39	-0.57	-0.16	-0.06	0.1	0.09	0.21
Grvc							1	-0.34	-0.21	-0.2	-0.14	-0.05	-0.05	0.05	0.13
Rocc								1	0.22	-0.01	0.23	0.01	-0.05	0	0.08
Graz									1	0.57	0.86	0.33	0.08	0.07	-0.41
Baso										1	0.18	0.14	-0.1	-0.11	-0.32
Dung											1	0.59	0.2	0.11	-0.38
Tram												1	0.22	-0.03	-0.33
Humd													1	0.38	0.03
Wild														1	0.17
Tons															1

Note: Alti = Altitude (m asl), Dist = Distance from Goth, Slop = Slope, Mois = Moisture, Shrc = Shrub cover (%), Grvc = Ground vegetation cover (%), Rocc = Rock cover (%), Graz = Grazing, Baso = Bare soil (%), Tram = Trampling, Humd = Human disturbance, Wild = Wildlife disturbance, Tons = Total number of species

Table G.2: Correlation between environmental variables for Gaurishankar Conservation Area (GCA)

	Alti	**Dist**	**Slop**	**PH**	**Mois**	**Shrc**	**Grvc**	**Rocc**	**Graz**	**Baso**	**Dung**	**Tram**	**Humd**	**Wild**	**Tons**
Alti	1	0	0.11	-0.04	0.03	0.11	-0.34	-0.09	0.05	0.28	-0.11	0.03	-0.09	0.05	0.14
Dist		1	0.06	0.33	0.06	0.05	-0.05	0.06	-0.44	-0.08	-0.62	-0.72	-0.21	-0.19	0.4
Slop			1	-0.05	-0.52	-0.12	-0.26	0.35	0.15	0.17	0.06	-0.01	-0.07	0.13	0.18
PH				1	0.34	0.11	-0.07	0.11	-0.28	-0.04	-0.32	-0.16	0.07	-0.18	0.07
Mois					1	-0.02	0.16	-0.03	-0.24	-0.11	-0.2	-0.04	-0.2	0.03	0.06
Shrc						1	-0.18	-0.12	-0.22	-0.43	0.02	-0.02	0.22	-0.08	-0.05
Grvc							1	-0.22	-0.35	-0.7	0.04	-0.1	-0.06	0.21	-0.16
Rocc								1	-0.24	-0.13	-0.22	-0.19	-0.19	-0.02	0.15
Graz									1	0.57	0.82	0.37	0.22	0.03	-0.18
Baso										1	0.03	0.19	-0.01	-0.13	0.12
Dung											1	0.47	0.31	0.11	-0.35
Tram												1	0.31	-0.05	-0.37
Humd													1	-0.21	-0.05
Wild														1	0
Tons															1

Note: Alti = Altitude (m asl), Dist = Distance from Goth, Slop = Slope, Mois = Moisture, Shrc = Shrub cover (%), Grvc = Ground vegetation cover (%), Rocc = Rock cover (%), Graz = Grazing, Baso = Bare soil (%), Tram = Trampling, Humd = Human disturbance, Wild = Wildlife disturbance, Tons = Total number of species

Table G.3: Correlation between environmental variables for Khaptad National Park (KNP)

	Alti	**Dist**	**Slop**	**PH**	**Mois**	**Shrc**	**Grvc**	**Rocc**	**Graz**	**Baso**	**Dung**	**Tram**	**Humd**	**Wild**	**Tons**
Alti	1	0	0.15	0.32	0.15	0.37	-0.2	0.13	-0.16	-0.32	-0.12	-0.1	0	0.13	0.1
Dist		1	-0.11	0.11	0.07	0.2	0.18	-0.06	-0.67	-0.44	-0.75	-0.79	-0.22	0	0.63
Slop			1	-0.1	-0.45	0.19	-0.23	0.04	0.003	0	0.02	0.09	0.05	0.13	-0.08
PH				1	0.2	0.24	-0.09	0.18	-0.2	-0.31	-0.17	-0.13	-0.07	0	0.1
Mois					1	0.11	-0.15	0.17	-0.08	-0.07	-0.1	-0.12	-0.04	-0.15	-0.02
Shrc						1	-0.68	0.12	-0.24	-0.53	-0.18	-0.18	-0.2	-0.07	0.14
Grvc							1	-0.4	-0.11	-0.08	-0.12	-0.14	0.07	0.01	0.14
Rocc								1	-0.16	-0.3	-0.08	0.04	-0.1	-0.1	-0.02
Graz									1	0.56	0.96	0.48	0.27	-0.06	-0.37
Baso										1	0.44	0.39	0.23	-0.04	-0.34
Dung											1	0.66	0.25	-0.06	-0.48
Tram												1	0.16	-0.06	-0.7
Humd													1	-0.1	-0.16
Wild														1	-0.06
Tons															1

Note: Alti = Altitude (m asl), Dist = Distance from Goth, Slop = Slope, Mois = Moisture, Shrc = Shrub cover (%), Grvc = Ground vegetation cover (%), Rocc = Rock cover (%), Graz = Grazing, Baso = Bare soil (%), Tram = Trampling, Humd = Human disturbance, Wild = Wildlife disturbance, Tons = Total number of species